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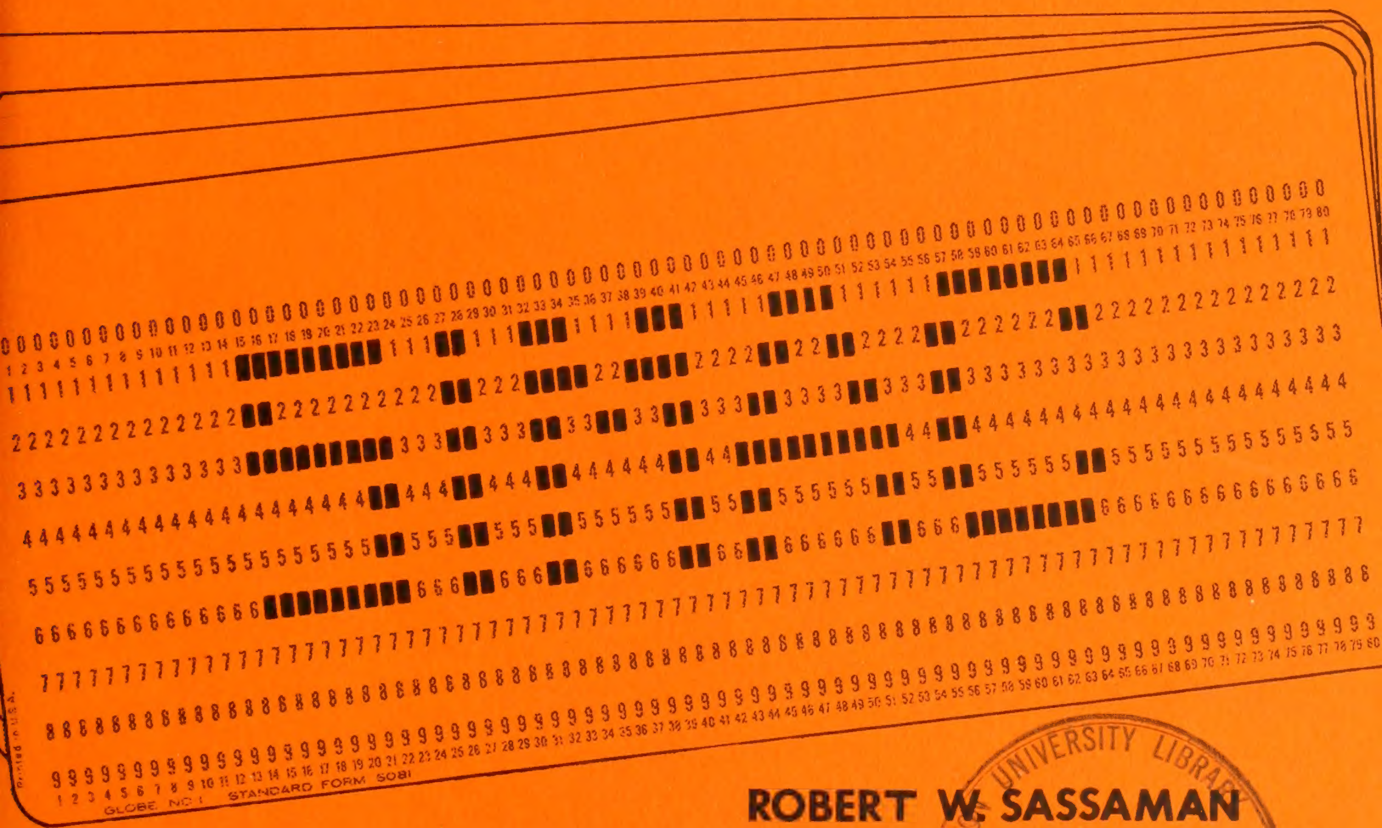
USER'S MANUAL FOR A COMPUTER PROGRAM FOR SIMULATING INTENSIVELY MANAGED ALLOWABLE CUT



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ABSTRACT

Detailed operating instructions are described for SIMAC, a computerized forest simulation model which calculates the allowable cut assuming volume regulation for forests with intensively managed stands. A sample problem illustrates the required inputs and expected output. SIMAC is written in FORTRAN IV and runs on a CDC 6400 computer with a SCOPE 3.3 operating system. The conceptual basis of the SIMAC method is not discussed in detail.

KEYWORDS: Allowable cut, programing (computer).

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CONTENTS

I. INTRODUCTION

The purpose of this manual is to describe the SIMAC[1/] computer program and to illustrate its use by detailed instructions and examples of the required input and expected output. The emphasis is entirely on providing the necessary information for operating the program; the conceptual basis of the method is being prepared by Karl Bergsvik.[2/]

SIMAC is a computerized forest simulation model that calculates the allowable cut associated with the stated forest management plan for even-aged stands. It can maximize an even flow of cut for some specified management regime, or a series of cuts may be specified for as many as the first 10 decades followed by even flow. It provides an alternative to earlier allowable cut computer programs, such as ARVOL,[3/] AREA,[4/] and SORAC,[5/] which were not designed to consider the effects of intensive management activities, and timber RAM,[6/] a multiple use management planning system based on linear programing principles.

SIMAC computes a harvest rate based on present inventory and projected growth resulting from some or all of the following management practices: mortality salvage, precommercial and commercial thinning, commercial thinning only, forest genetics, and final harvest cuts. Other treatments, such as fertilization, can be included in conjunction with one or more of the above treatments. SIMAC must be told what treatments to apply, when, and on how many acres. No rotation age is set: instead, a minimum cutting age constraint is specified. SIMAC is not designed to handle economic values or costs, and it does not seek out alternative schedules or strategies.

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[1] "SIMAC" is an acronym for *S*imulating *I*ntensively *M*anaged *A*llowable *C*ut. The conceptual basis and early COBOL version of the SIMAC program were developed by Karl Bergsvik and Don Deberard of the Bureau of Land Management, Portland and Denver Service Centers, respectively. The FORTRAN version reported here was developed by Ed Holt and Bob Sassaman of the U.S. Forest Service's Pacific Northwest Forest and Range Experiment Station in cooperation with the Bureau of Land Management.

[2] Bureau of Land Management, Portland Service Center.

[3] Daniel E. Chappelle. A computer program for calculating allowable cut using the area-volume check method. USDA Forest Serv. Res. Note PNW-44. Portland, Oreg., Pac. Northwest Forest & Range Exp. Stn., 4 p., 1966.

[4] Robert W. Sassaman and Daniel E. Chappelle. A computer program for calculating allowable cut using area regulation and a comparison with the ARVOL method. USDA Forest Serv. Res. Note PNW-63. Portland, Oreg., Pac. Northwest Forest & Range Exp. Stn., 7 p., 1967.

[5] Daniel E. Chappelle and Robert W. Sassaman. A computer program for scheduling allowable cut using either area or volume regulation during sequential planning periods. USDA Forest Serv. Res. Note PNW-93. Portland, Oreg., Pac. Northwest Forest & Range Exp. Stn., 9 p., 1968.

[6] Daniel I. Navon. Timber RAM . . . a long range planning method for commercial timber lands under multiple-use management. USDA Forest Serv. Res. Pap. PSW-70. Berkeley, Calif., Pac. Southwest Forest & Range Exp. Stn., 22 p., 1971.

II. PROGRAM CHARACTERISTICS

This section addresses the question, "What kinds of problems will SIMAC handle?" Program features are listed for the potential user to determine whether SIMAC is relevant to his timber harvest scheduling problem.

A. Program Operation--What SIMAC Does

Data for making allowable cut calculations for an area are read and printed.

1. Inventory volumes and annual growth rates are calculated and printed for the initial forest (if the print indicator is flagged).

Calculations are made for each of the decades (maximum of 40) in the testing period in steps 2 to 6 which follow. Acreages and volumes in each age class which will be treated in the decade are computed using criteria and data specified in the input.

2. Acreages to be treated (and intermediate harvest volume in steps 2a and 2d) in each age class during the decade are computed for each of the following:

   a. mortality salvage
   b. reforestation with genetically improved trees
   c. precommercial thinning
   d. commercial thinning

3. The final harvest volume and acreage are taken from age classes according to criteria supplied by user until the total chargeable volume equals the cut level being tested.

4. The acreage distribution at the beginning of the decade is adjusted for acreage treated and final acreage harvested during the decade.

5. The new acreage distribution is used to compute the volume and annual growth of the forest at the end of the decade. A summary of the activities of the decade is printed (if the print indicator is flagged), including: the acres that were treated and the treatment they received, the volume removed from commercial thinning and mortality salvage, the acres that were final harvest cut and their associated volumes, and the volume and growth of the stands remaining at the end of the decade.

6. When the projection period is completed, the standing volume and annual growth rate are checked to see if the trial allowable cut level is sustainable. If it is, the trial cut level is increased and the projection is repeated. If the cut is not sustainable, the trial cut level is decreased and the projection repeated. After all trial cut levels have been tested, the highest trial cut that was sustainable is used, and the projection is repeated for the last time with the print indicator flagged.

B. Description of SIMAC Features

The card-type numbers cited below are described in "SIMAC Input Data."

1. General

a. All input data assume an average site.[7]

b. A maximum of 52 age classes can be specified. Initial acreage in four basic treatment categories (nontreated, mortality salvage, genetic improvement, and thinned) must be provided for each age class (card-type 17).[8]

c. The allowable cut may be specified by the user for any of the first 10 decades (card-type 3). The trial cut level will be used in any decade for which an allowable cut is not specified by the user. For example, a user could specify a cut for decades 1, 2, 3, 6, 8, and 10. The trial allowable cut would then be used in decades 4, 5, 7, 9, 11, and all following decades.

d. The user must specify the percent that each age class is to contribute to the total volume of final harvest cut (card-type 20). An "oldest-first" harvest rule is implemented by entering 100 as the percent for age class 500.

e. Forest acreage can be modified by the user for decades 2 through 10. Land additions for practices such as site rehabilitation are treated as acreage of harvest cut in the previous decade. Land removals due to such practices as permanent road construction come from the acreage of harvest cut in the previous decade.

2. Yield Equations and Growth Equations

Eighteen yield equations are utilized in the SIMAC program. Described in the format of input data cards and coding forms (card-type 6), these apply to the calculation of final harvest volume, standing volume, and, in most cases, growth rate.

Eighteen growth equations are also utilized by SIMAC. These are the first derivatives of the yield equations and are determined by the program. The user can override six of these equations (for thinned stands less than 80 years old) by using his own growth equations (card-type 7).

3. Thinning

a. Thinning cycles of 5 through 10 years are acceptable. In any age class, all thinned stands fall in one of six categories: precommercial followed by commercial thinning, and no precommercial thinning with the first commercial thinning at age 30, 40, 50, 60, or 70 years.

b. For decades 1 through 10, the user specifies the percentage of acreage that will be precommercially thinned in age classes 10 and 20 (card-type 9) and the percentage of acreage that will be commercially thinned in age class 30 through age class 70 (card-type 10).

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[7] A three-site version of SIMAC is being developed.

[8] The effects of fertilization can also be included. Refer to item number 3g in "Description of SIMAC Features."

c. Volume tables are set by the user for intermediate harvests from commercial thinning. Six tables containing volumes per acre by age class and decade are read, one for each of the thinning categories. The user may specify growth equations for each of the thinning categories. If no growth equations are read, SIMAC uses the derivative of the yield equations for thinned stands plus the thinning volumes to determine growth rates.

d. Thinned stands have final harvest yield equations which are specified by the user (card-type 6). These equations are used to calculate final harvest volume and standing volume. If growth equations are not given, derivatives of the yield equations plus the volume from commercial thinnings determine the growth rates.

e. Acreage which can be thinned within a stand cannot be reduced (via input) from decade to decade except by clearcutting.

f. The first commercial thinning may begin as early as age 30 years. No commercial thinning cycle will be started that cannot be completed by age 80.

g. Any increased yields to be realized from the practice of fertilizing thinned stands must be reflected in the thinning yield data.

4. Mortality Salvage

a. Stands in age class 80 and older are eligible for mortality salvage operations.

b. An intermediate harvest volume table for mortality salvage is specified (card-type 16) which gives volumes per acre by age class and decade.

c. A yield equation must be provided for stands that have undergone mortality salvage (input card-type 6). This equation is used to determine final harvest volume and standing volume for stands 80 years old and older. For stands 80 through 120 years old the yield equation and the volume removed by mortality salvage are used to determine growth rates. The derivative of the yield equation and the volume removed by mortality salvage are used to calculate annual growth rates for stands greater than 120 years old.

d. Acreage in the mortality salvage category of an age class cannot be reduced by user inputs from decade to decade, except by clearcutting.

5. Genetic Improvements

a. Stands with genetic improvement are recognized at age 10 (card-type 8).

b. These stands are not thinned nor do they undergo mortality salvage operations.

c. Genetically improved stands have their own yield equations (card-type 6) for calculating final harvest volumes and standing volumes. The first derivatives of these equations are used to determine average annual growth rates.

d. SIMAC is not programed to accept intermediate harvests in genetically improved stands. However, intermediate harvests in these stands can be handled by increasing the yields of thinned stands.

6. Final Harvests

a. SIMAC determines the harvest volume each age class is to contribute toward the total final harvest volume based on the percentages previously described in item number 1d. To meet the volume contribution of the age class, the first harvest cut is in the nontreated stands, then the mortality salvaged stands, then the genetically improved stands, and finally the thinned stands.

b. Clearcut volumes are calculated on the basis of stand age at the middle of the decade.

c. No age class younger than the minimum cutting age will be clearcut. If not specified by the user, a minimum cutting age of 40 years is assumed.

d. If SIMAC schedules acres to be clearcut that have been thinned in the same decade, the volume from thinning is automatically decreased to avoid overstating the total harvest.

e. Acres scheduled for final harvest in a given decade will not undergo mortality salvage in the same decade.

f. Values produced by the nontreated yield equations and growth equations can be modified by the user over time for 12 ages (20, 30, . . . , 130) with the nontreated yield factors. Yield factors are averaged for nontreated stands and mortality-salvaged stands (card-types 18 and 19) for a yield factor for final harvests. For example, at age 85 the factors for age 80 in the program's current decade and age 90 in the next decade are averaged. For stands 140 years and older, the yield factor is assumed to be 1, since no change in yield is assumed in the future for these stands.

7. Stand Regeneration

Suppose that there is a harvest cut of 1,000 acres in a decade. SIMAC assumes these acres were cut at the rate of 100 acres per year. With a regeneration period of 5 years in the next decade, SIMAC would place 500 acres in the 1- through 5-year age class and 500 acres in the nonstocked class. With a regeneration period of 3 years, 200 acres would be assigned to the 10-year age class (ages 6-15), 500 acres to the 1- through 5-year age class, and 300 acres to the nonstocked class. The regeneration period is specified by the user as 0 through 10 years.

8. Volume and Annual Growth

Level of growing stock volumes and annual growths printed in the decade tables are calculated using ages at the end of the decade. A 30-year-old stand would use age 40 to calculate its volume and annual growth at the end of the decade.

9. Trial Allowable Cut Tests

a. SIMAC averages the high and low allowable cut limits (initially specified by the user) for a trial cut. At the end of the test period, the cut is determined as sustainable or not sustainable. If it is sustainable, the trial cut replaces the low limit; if it is not sustainable, it replaces the upper limit. A new trial cut is determined and the program is rerun. After the user-designated number of trial cuts (as indicated by TESTS, card-type 2) has been made, the highest cut that was sustainable is rerun with all the results printed.

b. If the designated number of trial cuts is tried and none found to be high, SIMAC uses the original upper limit as the cut and prints out the results. To obtain a more accurate calculation of the cut in such cases, a new run should be made with a higher allowable cut range.

c. If after the designated number of tests no cut was found to be sustainable, SIMAC uses the original lower limit as the cut and prints out the results. If the original lower limit is too high, a new run should be made with a lower allowable cut range.

d. When SIMAC is instructed to cut the trial allowable cut for up to 40 decades and is able to do so without exhausting the growing stock beforehand, it checks the total volume and the average annual growth between the next to the last and the last decade.

Four conditions are possible:

(1) Standing volume is increasing and total annual growth is increasing.
(2) Standing volume is increasing and total annual growth is decreasing.
(3) Standing volume is decreasing and total annual growth is increasing.
(4) Standing volume is decreasing and total annual growth is decreasing.

For cases 1 through 3, the allowable cut is assumed to be sustainable. For case 4, the allowable cut is depleting the resource and violates the even-flow principle.

C. SIMAC Input Data

In this section the input card types are listed, the variables on each card are defined, and a sample problem is shown on a SIMAC coding form. The input variables are also described at the beginning of the SIMAC listing.

SIMAC card-types

1. geographic identification
2. measurement units and miscellaneous information
3. specified allowable cuts for the first 10 decades
4. even-flow allowable cut range and minimum final harvest cutting age
5. land base adjustment by decade
6. yield equation coefficients
7. growth equation coefficients for thinned stands
8. genetic improvement percents
9. precommercial thinning percents
10. commercial thinning percents
11. mortality salvage percents
12. commercial thinning yield table for stands precommercially thinned
13. commercial thinning yield table for stands first thinned at age 30
14. commercial thinning yield table for stands first thinned at age 40
15. commercial thinning yield tables for stands first thinned at age 50, 60, or 70
16. mortality salvage yield table
17. initial acreage
18. yield factors for nontreated stands
19. yield factors for stands that have undergone mortality salvage
20. final harvest volume percents

Data for a typical west-side management unit (even-aged stands) have been developed and are shown on specially designed SIMAC coding forms in this section. The problem covers a 347,000-acre tract managed on an even-flow system of harvests with a 10-year thinning cycle and a 3-year regeneration period. The allowable cut is based on intermediate and final harvests and is affected by the following management practices: genetic improvement, precommercial thinning, commercial thinning, and mortality salvage operations.

Output for the sample problem includes a description of the basic data, an initial inventory, a description of the projected forest conditions by decades, and a decade summary (described in the "SIMAC Output" section of the manual). Though the program ran four tests, each 40 decades, only the outputs for the highest even-flow level of the projected forest for decades 1, 2, 39, and 40 are included in this manual.

Format of Input Data Cards and Coding Forms

Card-type 1: Geographic identification

Program code	Item	Format	Card columns
STATE (3)	Geographical identification	3A4	1-12
DIST (3)	" " (district)	3A4	13-24
SYAREA (3)	" " (sustained yield area)	3A4	25-36
INDAT (2)	Date of inventory	2A4	37-44
MGMSYS (2)	System of management (even flow or modulated flow)	2A4	45-52
SPECIE (3)	Identification of the predominant commercial species	3A4	53-64

SIMAC coding form with sample problem data

STATE	DISTRICT	SUSTAINED YIELD AREA	DATE OF INVENTORY	SYSTEM OF MANAGEMENT	COMMERCIAL SPECIES
1–12	13–24	25–36	37–44	45–52	53–64
P. N.W.	EXP. STATIØN	SAMPLE PRØB.	1/1/71	EVENAGE	DØUG, FIR

Card-type 2: Measurement units and miscellaneous information

Program code	Item	Format	Card columns
UNIT (2)	Unit of measurement used	2A4	1-8
RULE (2)	Log rule	2A4	9-16
UTILIZ (6)	Utilization standard (e.g., all trees, 9-inch d.b.h. to a 7-inch top)	6A4	17-40
SITE	Site index	A3	41-43
PVOL	Partial volume indicator. If PVOL equals: 1, thinning and mortality salvage are included in the allowable cut. 2, neither thinning nor mortality salvage is included in the allowable cut. 3, mortality salvage but not thinning is included in the allowable cut. 4, thinning but not mortality salvage is included in the allowable cut.	I1	44
LAG	Reforestation lag (years). The maximum lag is 10 years.	I2	45-46
TC	Thinning cycle (years). Five through 10 years is acceptable.	I2	47-48
BACRES	Base acreage.	I8	49-56
PER1	Ultimate percentage of any age class to undergo genetic improvement.	I2	57-58
PER2	Ultimate percentage of any age class to undergo commercial thinning.	I2	59-60
PER3	Ultimate percentage of any age class to undergo mortality salvage.	I2	61-62
SCUT	System of cut indicator. If SCUT equals 1, even flow. 2, modulated harvest.	I2	63-64
PRINT	Printed output indicator. The allowable cut is determined by an iterative technique (series of trial cuts). Only output from the final trial cut is printed unless PRINT is set equal to 1 (one)--then all trials are printed.	I1	68
TESTS	Number of trial allowable cuts. Before deciding on the number of trial allowable cuts (TESTS), the analyst should consider how precise the allowable cut calculation must be (e.g., nearest half-million board feet, or cubic feet, nearest million, etc.), and the confidence he has in his ability to select a range of allowable cut values that will include the allowable cut level which the program will calculate. How to select a value for TESTS and determine the allowable cut range: Pick some range in which you feel the highest sustainable allowable cut will fall. Adjust the range so that it equals some power of 2 times the unit of precision desired. Set TESTS equal to the exponent of 2.	I2	69-70

Program code	Item	Format	Card columns
TESTS (continued)	For example, suppose you want the highest sustainable allowable cut to the closest million board feet (MMBF) and you think it is between 150 and 200 MMBF per decade. You want the range to equal 2^n x (unit of precision). 2^n x 1 MMBF = 200 MMBF - 150 MMBF 2^n x 1 MMBF = 50 MMBF 2^n = 50 So n = between 5 and 6 Which one should we use? We select n = 6 because it is the smallest power of 2 that will cover the range (50 MMBF) in which the cut is expected to occur (i.e., 2^6 x 1 MMBF = 64 MMBF which covers the 50 MMBF range, while 2^5 x 1 MMBF = 32 MMBF which does not cover the range). So TESTS equals 6 and our upper and lower limits are 143 MMBF and 207 MMBF. If you want the allowable cut to the nearest 0.5 MMBF, the range can be the same as above but change TESTS to 7 since 2^7 x 0.5 MMBF = 64 MMBF.		
TDEC	Number of decades for each trial (maximum of 40)	I2	71-72

SIMAC coding form with sample problem data

UNIT OF MEASURE — LOG RULE — UTILIZATION STANDARD — SITE INDEX — PART. VOL. — REGEN. LAG — THIN. CYCLE — BASE ACREAGE — FG % — CT % — MS % — SYSTEM OF CUT — PRINT INSTRUCTIONS — NUMBER OF TESTS — DECADES PER TEST

BD. FT. INT. 1/8" 7" DBH TO FIXED 5" TOP 140 1 3 10 347000 75 25 3 1 1 3 40

CODE EXPLANATION:

PARTIAL VOLUME

1 - Thinning and mortality salvage included in the allowable cut.
2 - Thinning and mortality salvage not included in the allowable cut.
3 - Thinning not included in the allowable cut.
4 - Mortality salvage not included in the allowable cut.

SYSTEM OF CUT

1 - Even flow.
2 - Modular.

PRINT INSTRUCTIONS

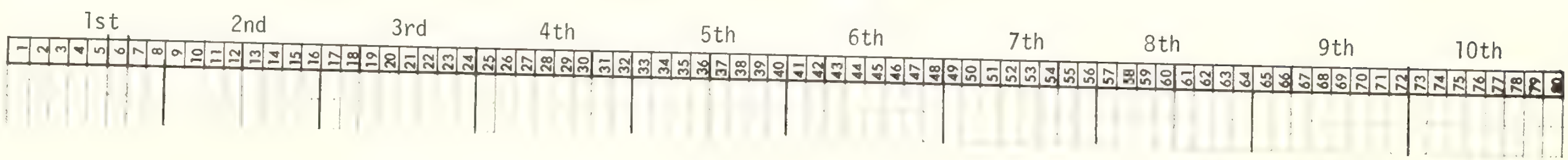
1 - Print all tests.
Blank - Print last test only.

Card-type 3: Specified allowable cuts for the first 10 decades

Program code	Item	Format	Card columns
ACUT (10)	Allowable cut levels to be used the first 10 decades of the projection. For any decade an allowable cut level is not specified, the even-flow level is used. This card is read but ignored if the system of cut (SCUT) on the previous card is 1.	F8.0 F8.0 F8.0 etc.	1- 8 9-16 17-24 etc.

SIMAC coding form with sample problem data

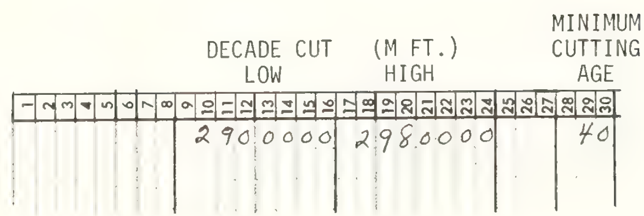
ALLOWABLE CUT BY DECADE (M FT.)



Card-type 4: Even-flow allowable cut range and minimum final harvest cutting age

Program code	Item	Format	Card columns
ACL	Initial lower limit of the even-flow allowable cut range (M ft. per decade)	F8.0	9-16
ACH	Initial upper limit of the even-flow allowable cut range (M ft. per decade)	F8.0	17-24
MINAG	Minimum age clearcutting is allowed. If a value is not read, 45 years is assumed to be the minimum acceptable age for clearcutting.	I3	28-30

SIMAC coding form with sample problem data

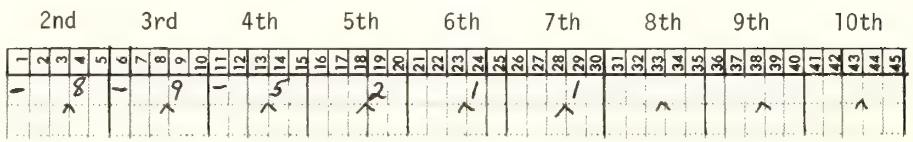


Card-type 5: Land base adjustment by decade

Program code	Item	Format	Card columns
PADJ (10)	Percent of base acreage (from card-type 2) to be added or subtracted from the total forest acreage in decades 2 through 10. Variable PADJ(1) is not used. Land removed comes from the acreage clearcut in the preceding decade and cannot exceed the acreage clearcut. Land added is treated the same as acreage clearcut in the preceding decade. A blank card is acceptable.	F5.2	1- 5
		"	6-10
		"	11-15
		"	16-20
		"	21-25
		"	26-30
		"	31-35
		"	36-40
		"	41-45

SIMAC coding form with sample problem data

ACREAGE ADJUSTMENT BY DECADE
(PERCENT OF BASE ACREAGE)



Program code	Item	Format	Card columns
Y(2,9,3,)	Eighteen cards are used to input coefficients for 18 yield equations	F15.7	1-15
	These equations are divided into two sets:		
	1. Stands less than 80 years old	F15.7	16-30
	2. Stands 80 years and older	F15.7	31-45
	Both sets contain nine equations, one for each of the following treatments:		
	1. Nontreated		
	2. Mortality salvage		
	3. Forest genetics		
	4. First commercially thinned at age 70		
	5. First commercially thinned at age 60		
	6. First commercially thinned at age 50		
	7. First commercially thinned at age 40		
	8. First commercially thinned at age 30		
	9. Precommercially thinned and then commercially thinned		
	Each card contains three coefficients, Y(I,J,1), Y(I,J,2), Y(I,J,3) to be used in an equation of the form Y(I,J,1) + (Y(I,J,2) * AGE) + (Y(I,J,3) * AGE^2) = yield per acre. A blank card is acceptable for any given yield equation.		

SIMAC coding form with sample problem data

YIELD EQUATIONS FOR STANDS LESS THAN 80 YEARS OLD

Y(1,J,1) (cols 1-15)	Y(1,J,2) (cols 16-30)	Y(1,J,3) (cols 31-45)	TREATMENT
-90056334	90574817	-20421798	nontreated
-92660000	87170943	-19604286	mortality salvage
-403992430	178416300	-61306594	forest genetics
-1139057100	446571430	-317142860	first commercially thinned at age 70
-1139057100	446571430	-317142860	first commercially thinned at age 60
-1139057100	446571430	-317142860	first commercially thinned at age 50
-210436000	137233000	-75700000	first commercially thinned at age 40
-210436000	137233000	-75700000	first commercially thinned at age 30
-210436000	137233000	-75700000	precommercially and then commercially thinned

YIELD EQUATIONS FOR STANDS 80 YEARS OLD AND OLDER

Y(2,J,1) (cols 1-15)	Y(2,J,2) (cols 16-30)	Y(2,J,3) (cols 31-45)	TREATMENT
-90056334	90574817	-20421798	nontreated
-92660000	87170943	-19604286	mortality salvage
-403992430	178416300	-61306594	forest genetics
-2830400000	697714290	-334285710	first commercially thinned at age 70
-875700000	241071430	-81428571	first commercially thinned at age 60
-707200000	200000000	-60000000	first commercially thinned at age 50
-1192818500	279022130	-90527932	first commercially thinned at age 40
-1192818500	279022130	-90527932	first commercially thinned at age 30
-1192818500	279022130	-90527932	precommercially and then commercially thinned

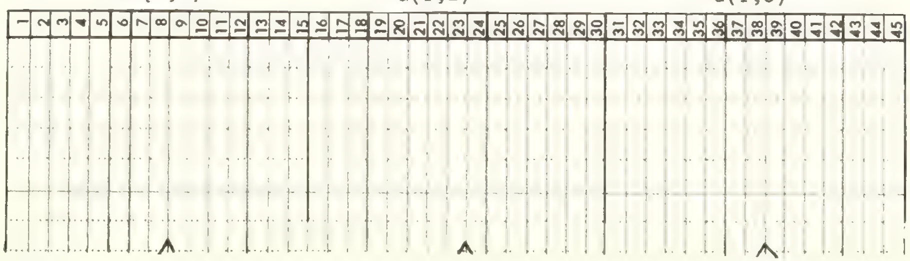
Card-type 7: Growth equation coefficients for thinned stands

Program code	Item	Format	Card columns
G(6,3)	Six cards are used to input coefficients for six growth equations. One equation is read for each of the following:		
	1. Stands first commercially thinned at age 70	F15.7	1-15
	2. Stands first commercially thinned at age 60	"	16-30
	3. Stands first commercially thinned at age 50	"	31-45
	4. Stands first commercially thinned at age 40		
	5. Stands first commercially thinned at age 30		
	6. Stands precommercially thinned and then commercially thinned		
	Each card contains three coefficients, G(I,1), G(I,2), G(I,3), to be used in an equation of the form G(I,1) + (G(I,2) * AGE) + (G(I,3) * AGE^2) = growth per acre.		
	If the growth coefficient card for a thinning treatment is left blank, SIMAC uses the first derivative of that treatment's yield equation for stands less than 80 years old plus the volume from commercial thinning to calculate growth.		

SIMAC coding form with sample problem data

GROWTH EQUATIONS FOR THINNED STANDS LESS THAN 80 YEARS OLD

G(I,1) G(I,2) G(I,3)



TREATMENT

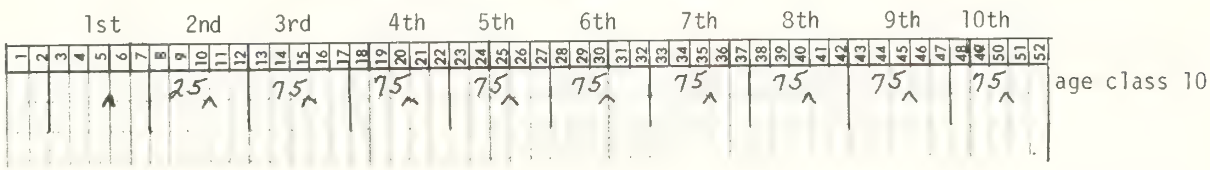
first commercially thinned at age 70
first commercially thinned at age 60
first commercially thinned at age 50
first commercially thinned at age 40
first commercially thinned at age 30
precommercially and then commercially thinned

Card-type 8: Genetic improvement percents

Program code	Item	Format	Card columns
GEN(10)	Percentage of the acreage in age class 10 to undergo forest genetic improvement in decades 1 through 10. The percent shown for decade 10 also applies to decades 11 on. A blank card is acceptable. If any value is read, or if the initial forest has genetically improved acres, the appropriate yield equations must be read on card-type 6.	F5.2	3- 7
		"	8-12
		"	13-17
		"	18-22
		"	23-27
		"	28-32
		"	33-37
		"	38-42
		"	43-47
		"	48-52

SIMAC coding form with sample problem data

GENETIC IMPROVEMENT (% BY DECADE)



Card-type 9: Precommercial thinning percents

Program code	Item	Format	Card columns
PT(7,10)	The first two rows of PT(7,10) contain the percent of the acreage in age classes 10 and 20 that will undergo precommercial thinning and later commercial thinning in decades 1 through 10. Two cards are needed, one for each age class. The percents shown for decade 10 apply to decades 11 on.	F5.2	3- 7
		"	8-12
		"	13-17
		"	18-22
		"	23-27
	Any precommercial thinning in a 20-year-old stand is in addition to the acres precommercially thinned of that stand at age 10. Blank cards are acceptable. If any value is read, or if the initial forest has stands that were precommercially thinned, appropriate yield equations (card-type 6) and the commercial thinning yield table for stands precommercially thinned (card-type 12) must be read.	"	28-32
		"	33-37
		"	38-42
		"	43-47
		"	48-52

SIMAC coding form with sample problem data

PRECOMMERCIAL THINNING (% BY DECADE)

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	
12	8	8	8	8	8	8	8	8	8	age class 10
40^	13^	17^	17^	17^	17^	17^	17^	17^	17^	age class 20

Card-type 10: Commercial thinning percents

Program code	Item	Format	Card columns
PT(7,10)	The last five rows of PT(7,10) contain commercial thinning percents. Five cards are used as input for the percent of the acreage in age classes 30 through 70 that will be commercially thinned in the first thinning to begin in each of the first 10 decades. Decades 11 on use the same percents as decade 10.	F5.2	3- 7
		"	8-12
		"	13-17
		"	18-22
		"	23-27
	The acreage in a stand to undergo commercial thinning can be increased by increasing the percent to thin over time, but the acreage cannot be decreased. Once an acre is placed in the thinned category, it is rethinned every thinning cycle until it reaches age 80 or harvest cut. Blank cards are acceptable. For any thinning treatment used during the projection period, the user must supply the appropriate yield equations (card-type 6) and the appropriate commercial thinning yield table (card-type 12, 13, 14, or 15).	"	28-32
		"	33-37
		"	38-42
		"	43-47
		"	48-52

SIMAC coding form with sample problem data

COMMERCIAL THINNING (% BY DECADE)

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	AGE CLASS
25	40	25	25	25	25	25	25	25	25	30
18	25	40	25	25	25	25	25	25	25	40
15	42	25	40	25	25	25	25	25	25	50
20	25	42	25	40	25	25	25	25	25	60
35	45	25	42	25	40	25	25	25	25	70

Program code	Item	Format	Card columns
IK	Physical control variable for mortality salvage input. Mortality salvage can take place in 43 age classes. In situations where fewer than 43 classes have mortality salvage data, the IK field of the last mortality salvage percent data card should be set equal to 99. This eliminates the need to read a blank card for each remaining age class.	I2	1- 2
PMS(43,10)	Percent of the acreage in 10-year age classes 80 through 500 to undergo mortality salvage treatment in decades 1 through 10. The percents used in decade 10 apply to decades 11 on. Each card contains the percents for one age class; card 1 applies to age class 80, card 43 to age class 500. The acreage in a stand to receive mortality salvage treatment can be increased by increasing the percent to be salvaged over time. This acreage cannot be decreased; once an acre is placed in the mortality salvage category, it undergoes mortality salvage treatment every decade until it is harvested. If any value is read, or if the initial forest has acreage that has undergone mortality salvage treatment, appropriate yield equations (card-type 6) and the mortality salvage yield table (card-type 16) must be read.	F5.2 " " " " " " " " "	3- 7 8-12 13-17 18-22 23-27 28-32 33-37 38-42 43-47 48-52

SIMAC coding form with sample problem data

MORTALITY SALVAGE (% BY DECADE)

IK	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	AGE CLASS
	3	4	3	3	3	3	3				80
	3	4	3	3	3	3	3				90
	3	4	4	3	3	3	3				100
	3	4	4	4	3	3	3				110
	3	4	4	4	4	3	3				120
	3	4	4	4	4	4	3				130
	6	5	4								140
	6	6	5								150
	6	6	6								160
	6	6	6								170
	6	6	6								180
	4	6	6								190
	4	4	6								200
	4	4	4								210
	4	4	4								220
	4	4	4								230
	12	4	4								240
	12	12	4								250
	12	12	12								260
	12	12	12								270
	12	12	12								280
		12	12								290
			12								300
99	10	13	3								310
											. . .

IK - If IK is set to 99, reading skips to commercial thinning volumes.

Card-type 12: Commercial thinning yield table for stands precommercially thinned

Program code	Item	Format	Card columns
VCT(6,7,10)	Seven cards are used as input for a thinning volume table for stands that have been precommercially thinned. This table gives volume per acre from commercial thinning practices on stands that have been precommercially thinned by thinning number and the decade the thinning begins. The first commercial thinning always begins at age 30 for these stands. Decades 8 on use the same volumes as decade 7. Blank cards are acceptable.	F5.0	3- 7
		"	8-12
		"	13-17
		"	18-22
		"	23-27
		"	28-32
		"	33-37
		"	38-42
		"	43-47
		"	48-52

SIMAC coding form with sample problem data

COMMERCIAL THINNING VOLUME (FT.) FOR STANDS THAT HAVE BEEN PRECOMMERCIALLY THINNED

Thinning Number (First Thinning Begins at Age 30)

1 (cols 3-7)	2 (cols 8-12)	3 (cols 13-17)	4 (cols 18-22)	5 (cols 23-27)	6 (cols 28-32)	7 (cols 33-37)	8 (cols 38-42)	9 (cols 43-47)	10 (cols 48-52)	DECADE THINNING BEGINS
										1st
8000										2nd
8000	11000									3rd
8000	10500	10000								4th
8000	10500	9500	9000							5th
8000	10500	9500	9000	9000						6th
8000	10500	9500	9000	9000						7th

EXPLANATION: If TC=5, the last thinning is the 10th, beginning at age 75.
If TC=6, the last thinning is the 9th, beginning at age 72.
If TC=7, the last thinning is the 8th, beginning at age 72.
If TC=8, the last thinning is the 7th, beginning at age 70.
If TC=9, the last thinning is the 6th, beginning at age 66.
If TC=10, the last thinning is the 5th, beginning at age 70.

TC is thinning cycle read on card-type 2.

Card-type 13: Commercial thinning yield table for stands first thinned at age 30

Program code	Item	Format	Card columns
VCT(6,7,10)	Seven cards are used as input for a thinning volume table for stands that are not precommercially thinned and are commercially thinned for the first time at age 30. This table gives volume per acre from thinning practices by thinning number and the decade the thinning begins. Decades 8 on use the same volumes as decade 7. Blank cards are acceptable.	F5.0	3- 7
		"	8-12
		"	13-17
		"	18-22
		"	23-27
		"	28-32
		"	33-37
		"	38-42
		"	43-47
		"	48-52

SIMAC coding form with sample problem data

COMMERCIAL THINNING VOLUME (FT.) FOR STANDS FIRST THINNED AT AGE 30

Thinning Number

1	2	3	4	5	6	7	8	9	10	DECADE THINNING BEGINS
1000										1st
	9000									2nd
		10000								3rd
			9000							4th
				8000						5th
										6th
										7th

Card-type 14: Commercial thinning yield table for stands first thinned at age 40

Program code	Item	Format	Card columns
VCT(6,7,10)	Seven cards are used as input for a thinning volume table for stands that are not precommercially thinned and are commercially thinned for the first time at age 40. This table gives volume per acre from thinning practices by thinning number and the decade the thinning begins. Decades 8 on use the same volumes as decade 7. Blank cards are acceptable.	F5.0	3- 7
		"	8-12
		"	13-17
		"	18-22
		"	23-27
		"	28-32
		"	33-37
		"	38-42

SIMAC coding form with sample problem data

COMMERCIAL THINNING VOLUME (FT.) FOR STANDS FIRST THINNED AT AGE 40

Thinning Number

1	2	3	4	5	6	7	8	DECADE THINNING BEGINS
9000								1st
	11000							2nd
		10000						3rd
			7000					4th
								5th
								6th
								7th

Card-type 15: Commercial thinning yield tables for stands first thinned at age 50, 60, or 70

Program code	Item	Format	Card columns
VCT(6,7,10)	Seven cards are used as input for three thinning volume tables. These tables are for stands that are not precommercially thinned and are commercially thinned for the first time at either age 50, 60, or 70. These tables give volume per acre from thinning practices by thinning number and the decade the thinning begins. Decades 8 on use the same volumes as decade 7. Blank cards are acceptable.	F5.0	3- 7
		"	8-12
		"	13-17
		"	18-22
		"	23-27
		"	28-32
		"	39-43
		"	44-48
		"	49-53
		"	54-58
		"	65-69
		"	70-74

SIMAC coding form with sample problem data

COMMERCIAL THINNING VOLUME (FT.) FOR STANDS FIRST THINNED AT AGE 50 — Thinning Number 1	2	3	4	5	6	COMMERCIAL THINNING VOLUME (FT.) FOR STANDS FIRST THINNED AT AGE 60 — Thinning Number 1	2	3	4	COMMERCIAL THINNING VOLUMF (FT.) FOR STANDS FIRST THINNED AT AGE 70 — Thinning Number 1	2	DECADE THINNING BEGINS
11000						14000				18000		1st
	13000						16000					2nd
		10000										3rd
												4th
												5th
												6th
												7th

Card-type 16: Mortality salvage yield table

Program code	Item	Format	Card columns
IK	See description of IK on input card-type 11.	I2	1- 2
VMS(43,7)	Volume (per acre) from mortality salvage in stands 80 years through 500 years old for the first 7 decades. These volumes correspond to the mortality salvage percentages on card-type 11. Volumes used in decade 7 apply to decades 8 on. A maximum of 43 cards can be read.	F8.0	3-10
		"	11-18
		"	19-26
		"	27-34
		"	35-42
		"	43-50
		"	51-58

SIMAC coding form with sample problem data

MORTALITY SALVAGE VOLUME (FT.)

IK	1st	2nd	3rd	4th	5th	6th	7th	AGE CLASS
	7000	5500	4000	4000	4000	4000	4000	80
	7000	5500	4000	4000	4000	4000	4000	90
	7000	5500	4000	4000	4000	4000	4000	100
	7000	5500	4000	4000	4000	4000	4000	110
	7000	5500	4000	4000	4000	4000	4000	120
	7000	5000	2500					130
	7000	5000	2500					140
	7000	5000	2500					150
	7000	5000	2500					160
	7000	5000	2500					170
	6000	6000	2500					180
	6000	6000	2500					190
	6000	6000	2500					200
	6000	6000	2500					210
	6000	6000	2500					220
	7000	6000	2500					230
	7000	6000	2500					240
	7000	6000	2500					250
	7000	6000	2500					260
	7000	6000	2500					270
		6000	2500					280
			2500					290
	8000	6000	2500					300
		6000	2500					310
99			2500					320
								⋮
								500

IK - If IK is set to 99, reading skips to initial acreage.

Card-type 17: Initial acreage

Program code	Item	Format	Card columns
IK	Physical control variable for the initial acreage data. Initial acreage cards must be read for the first 10 age classes (nonstocked, 1 through 5, 10, 20, . . . , 80). After these, cards need to be read only for age classes with acreage. If fewer than the maximum of 52 cards are read, assign IK a value of 99 on the last card and reading will skip to nontreated yield factors.	I2	1- 2
JL(6)	Used to input the initial acreage data.		
	JL(1) - Age class of the acreage on the same card (90, 100, . . . , 500).	I3	3- 5
	JL(2) - Nontreated acreage.	I10	6-15
	JL(3) - Mortality salvage acreage. JL(3) is not read for age classes less than 90 years old.	I10	16-25
	JL(4) - Genetically improved acreage. JL(4) is not read for age classes less than 20 years old.	I10	26-35
	JL(5) - Thinned acreage. JL(5) is not read for age classes less than 20 years old.	I10	36-45
	JL(6) - The age at which the acreage in JL(5) was first thinned if it was not precommercially thinned. If the acres in JL(5) were precommercially thinned, leave JL(6) blank.	I2	46-47

INITIAL ACREAGE BY AGE CLASS AND TYPE

IK	AGE	NONTREATED	MORTALITY SALVAGE	FOREST GENETICS	THINNED	AGE FIRST THINNED
	N/S	20000				
	1-5	20000				
	10	40000				
	20	30000				
	30	30000				
	40	15000				
	50	15000				
	60	15000				
	70	20000				
	80	30000				
	90	25000				
	100	10000				
	110	15000				
	120	10000				
	130	5000				
	140	5000				
	150	1000				
	160	1000				
	170	500				
	180	1000				
	190	500				
	200	2000				
	210	500				
	220	1000				
	230	500				
	240	500				
	260	2500				
	270	1000				
	280	1000				
	290	2000				
99	300	27000				

Cards for the first 10 age classes must be read. After age class 80, age classes without any acreage can be omitted.

Enter in columns 46 and 47 the age at which commercial thinning was first started. If the stand was precommercially thinned, leave the two columns blank.

If IK is set to 99, reading skips to nontreated yield factors.

Program code	Item	Format	Card columns
NTYF(12,10)	Nontreated yield factors for 12 ages (20, 30, . . . , 130) at the beginning of the first 10 decades allow the user to modify, over time, the values produced by the nontreated yield equation and growth equations.	F5.3	3- 7
		"	8-12
		"	13-17
		"	18-22
	The initial inventory table uses factors for the beginning of the first decade in calculating volume and growth. The volumes and growth rates for nontreated stands at the end of the first decade use the factors for the beginning of the second decade. In the sample data below, a nontreated stand 40 years old at the beginning of the third decade (the end of the second decade) is expected to produce 90 percent of the volume per acre given by the nontreated yield equation. A nontreated stand in the 90-year age class at the beginning of the second decade will use age 95 and a yield factor of 1.025 in calculating volume per acre from harvest cutting. 1.025 is determined by averaging the yield factor of 1.020 for a stand 90 years old at the beginning of the second decade and the yield factor of 1.030 for a stand 100 years old at the beginning of the third decade. Nontreated stands 140 years old and older use 1.000 for a yield factor. Decades 11 on use the same factors as decade 10.	"	23-27
		"	28-32
		"	33-37
		"	38-42
		"	43-47
	Twelve cards are read, one for each age class 20 through 130. Blank cards are acceptable. SIMAC assumes a value of 1.000 for any blank field.	"	48-52

SIMAC coding form with sample problem data

PROJECTION OF PRESENT YIELDS AND GROWTH FOR NONTREATED STANDS
AT THE BEGINNING OF THE FIRST 10 DECADES

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	STAND AGE
	800	700	600	550	500	450	400	350	300	20
	950	850	800	700	650	600	550	500	450	30
	950	900	900	850	800	800	750	700	700	40
			950	950	950	900	900	900	900	50
		1010	1010	1010	1015	1015	1020	1025	1030	60
	1010	1020	1040	1050	1060	1080	1090	1100	1110	70
	1020	1030	1050	1070	1090	1100	1120	1140	1140	80
	1020	1030	1050	1070	1090	1100	1120	1140	1140	90
	1015	1030	1040	1060	1080	1090	1100	1120	1120	100
	1015	1020	1040	1050	1060	1080	1090	1100	1100	110
	1010	1020	1040	1050	1060	1080	1090	1100	1100	120
	1010	1020	1040	1050	1060	1080	1090	1100	1100	130

Card-type 19: Yield factors for stands that have undergone mortality salvage

Program code	Item	Format	Card columns
MYF(6,10)	Mortality salvage yield factors for six ages (80, 90, . . . , 130) at the beginning of the first 10 decades give the user a means to change, over time, the yields and growths produced by the mortality salvage yield equation and growth equation. The mortality salvage yield factors are used on stands that have undergone mortality salvage in the same manner the nontreated yield factors are used on nontreated stands as described for card-type 18. Six cards are read, one for each age class. Blank cards are acceptable. SIMAC assumes a value of 1.000 for any blank field.	F5.3	3- 7
		"	8-12
		"	13-17
		"	18-22
		"	23-27
		"	28-32
		"	33-37
		"	38-42
		"	43-47
		"	48-52

SIMAC coding form with sample problem data

PROJECTION OF PRESENT YIELDS AND GROWTH FOR MORTALITY SALVAGE STANDS AT THE BEGINNING OF THE FIRST 10 DECADES

1st	2nd	3rd	4th	5th	6th	7th	3th	9th	10th	STAND AGE
	1020	1030	1050	1070	1090	1100	1120	1140	1140	80
	1020	1030	1050	1070	1090	1100	1120	1140	1140	90
	1020	1030	1040	1060	1080	1090	1100	1120	1120	100
	1010	1020	1040	1050	1060	1080	1090	1100	1100	110
	1010	1020	1040	1050	1060	1080	1090	1100	1100	120
^	1^010	1^020	1^040	1^050	1^060	1^080	1^090	1^100	1^100	130

Card-type 20: Final harvest volume percents

Program code	Item	Format	Card columns
PAC(52)	Three cards are read stating for each age class that is at least 40 years old the percent of the harvest cut to be removed. Percents are read only at the beginning of the first decade and accumulate downward (i.e., by decreasing age) as age classes are eliminated by harvesting. For example, in the sample problem 2 percent of the cut is to come from age class 300 and 2 percent from age class 290. If age class 300 has no volume, SIMAC will try to remove 4 percent from age class 290. If age class 300 can provide only 1 percent of the cut, SIMAC will attempt to remove 3 percent from age class 290. An "oldest-first" harvest rule is implemented by entering 100 as the percent for age class 500 and leaving all other fields blank. Caution! The age when cut of some stands in the next several decades may exceed the age of the oldest initial age class. Therefore, allow for this when selecting the PAC values. Note in the example that a PAC value was used for age class 350 but the oldest initial class is only 300 years.	F5.2	1- 5
		"	6-10
		"	11-15
		"	16-20
		"	21-25
		"	26-30
		"	31-35
		"	36-40
		"	41-45
		"	46-50
		"	51-55
		"	56-60
		"	61-65
		"	66-70
		"	71-75
		"	76-80

SIMAC coding form with sample problem data

PERCENT OF TOTAL FINAL HARVEST VOLUME TO BE CUT FROM EACH AGE CLASS

40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
				8	8	8	8	8	24	24	24	24	24	12	12

200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
12	12	12	1	1	1	1	1	2	2	2	2	2			27

360	370	380	390	400	410	420	430	440	450	460	470	480	490	500	

D. SIMAC Output

SIMAC determines the sustainable allowable cut by an iterative technique. Printed output is controlled by the variable "PRINT." Normally on production runs, only the final trial cut results are printed. On test runs, a print of an intermediate output may be of considerable value. For example, when the trial cut is too large it may be of interest to see the changes in stand structure by decades as the amount of harvestable timber declines.

A description of the printed output follows. There are four distinct sections of the format which remain unchanged from one trial cut to another. They are: a listing of the basic data entered, an initial inventory (acres and volume by age class), a description of the projected forest by decades, and a trial cut summary by decade. Each section is described in detail.

1. Basic Data

This section appears at the beginning of each trial cut printout and lists all the initial input. An example, using the sample problem, follows.

```
09/20/72                                   * *  INPUT  * *                                        PAGE   1

                                          SUSTAINED          DATE OF          SYSTEM OF          COMMERCIAL
      STATE              DISTRICT         YIELD AREA         INVENTORY        MANAG MENT          SPECIES

      F.N.W.             EXP. STATION     SAMPLE PROB.        1/1/71           EVENAGE            DOUG. FIR

UNIT OF                                   SITE  PART. REGEN THIN    BASE     ULTIMATE PERCENT  SYS
MEASURE     LOG RULE    UTILIZATION STANDARD  INDEX  VOL   LAG  CYCLE  ACREAGE   FG    CT    MS  CUT  PRINT TESTS DECAD

BD.FT.      INT 1/8"    7"DBH TO FIXED 5"TOP  140    1     3    10    347000    75%   25%   3%  1    1     3     40

                                           ALLOWABLE CUT  (M. FT.)

1ST DECADE  2ND DECADE  3RD DECADE  4TH DECADE  5TH DECADE  6TH DECADE  7TH DECADE  8TH DECADE  9TH DECADE  10TH DECADE

  2940000     2940000     2940000     2940000     2940000     2940000     2940000     2940000     2940000     2940000

   INITIAL ALLOWABLE CUT RANGE  (M. FT.)
                                                MINIMUM
        LOW              HIGH               CUTTING AGE

      2900000          2980000                  40

                          ACREAGE ADJUSTMENT BY DECADE - PERCENT OF BASE ACREAGE

   2ND DECADE   3RD DECADE   4TH DECADE   5TH DECADE   6TH DECADE   7TH DECADE   8TH DECADE   9TH DECADE   10TH DECADE

     -.80         -.40         -.50          .20          .10          .10
```

In the sample problem, the growth equation cards were left blank; therefore, on the output the growth equations printed are the derivatives of the appropriate yield equations.

09/20/72   * * INPUT * *   PAGE 2

YIELD EQUATIONS FOR STANDS LESS THAN 80 YEARS OLD   Y = A + B*AGE + C*(AGE**2)

TREATMENT	A	B	C
NON-TREATED	-9005.6334000	905.7481700	-2.0421798
MORTALITY SALVAGE	-9266.0000000	871.7094300	-1.9604286
FOREST GENETICS	-40399.2430000	1784.1630000	-6.1306594
FIRST C.T. AT AGE 70	-113905.7100000	4465.7143000	-31.7142860
FIRST C.T. AT AGE 60	-113905.7100000	4465.7143000	-31.7142860
FIRST C.T. AT AGE 50	-113905.7100000	4465.7143000	-31.7142860
FIRST C.T. AT AGE 40	-21043.6000000	1372.3300000	-7.5700000
FIRST C.T. AT AGE 30	-21043.6000000	1372.3300000	-7.5700000
P.C.T. AND THEN C.T.	-21043.6000000	1372.3300000	-7.5700000

YIELD EQUATIONS FOR STANDS 80 YEARS OLD AND OLDER   Y = A + B*AGE + C*(AGE**2)

TREATMENT	A	B	C
NON-TREATED	-9005.6334000	905.7481700	-2.0421798
MORTALITY SALVAGE	-9266.0000000	871.7094300	-1.9604286
FOREST GENETICS	-40399.2430000	1784.1630000	-6.1306594
FIRST C.T. AT AGE 70	-283040.0000000	6977.1429000	-33.4285710
FIRST C.T. AT AGE 60	-87570.0000000	2410.7143000	-8.1428571
FIRST C.T. AT AGE 50	-70720.0000000	2000.0000000	-6.0000000
FIRST C.T. AT AGE 40	-119281.8500000	2790.2213000	-9.0527932
FIRST C.T. AT AGE 30	-119281.8500000	2790.2213000	-9.0527932
P.C.T. AND THEN C.T.	-119281.8500000	2790.2213000	-9.0527932

GROWTH EQUATIONS FOR THINNED STANDS LESS THAN 80 YEARS OLD   Y = A + B*AGE + C*(AGE**2)

TREATMENT	A	B	C
FIRST C.T. AT AGE 70	4465.7143000	-63.4285720	
FIRST C.T. AT AGE 60	4465.7143000	-63.4285720	
FIRST C.T. AT AGE 50	4465.7143000	-63.4285720	
FIRST C.T. AT AGE 40	1372.3300000	-15.1400000	
FIRST C.T. AT AGE 30	1372.3300000	-15.1400000	
P.C.T. AND THEN C.T.	1372.3300000	-15.1400000	

09/20/72   * * INPUT * *   PAGE

GENETIC IMPROVEMENT (% BY DECADE)

	1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH
AGE CLASS 10 -		25.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00

PRE-COMMERCIAL THINNING (% BY DECADE)

	1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH
AGE CLASS 10 -	12.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
AGE CLASS 20 -	4.00	13.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00

COMMERCIAL THINNING (% BY DECADE)

	1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH
AGE CLASS 30 -	25.00	40.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
AGE CLASS 40 -	18.00	25.00	40.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
AGE CLASS 50 -	15.00	42.00	25.00	40.00	25.00	25.00	25.00	25.00	25.00	25.00
AGE CLASS 60 -	23.00	25.00	42.00	25.00	40.00	25.00	25.00	25.00	25.00	25.00
AGE CLASS 70 -	35.00	45.00	25.00	42.00	25.00	40.00	25.00	25.00	25.00	25.00

If no mortality salvage percent data are read, this page will not appear in the printout.

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MORTALITY SALVAGE (% BY DECADE)

		1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH
AGE CLASS 80	-	3.00	4.00	3.00	3.00	3.00	3.00	3.00			
AGE CLASS 90	-	3.00	4.00	3.00	3.00	3.00	3.00	3.00			
AGE CLASS 100	-	3.00	4.00	4.00	3.00	3.00	3.00	3.00			
AGE CLASS 110	-	3.00	4.00	4.00	4.00	3.00	3.00	3.00			
AGE CLASS 120	-	3.00	4.00	4.00	4.00	4.00	3.00	3.00			
AGE CLASS 130	-	3.00	4.00	4.00	4.00	4.00	4.00	3.00			
AGE CLASS 140	-	6.00	5.00	4.00							
AGE CLASS 150	-	6.00	6.00	5.00							
AGE CLASS 160	-	6.00	6.00	6.00							
AGE CLASS 170	-	6.00	6.00	6.00							
AGE CLASS 180	-	6.00	6.00	6.00							
AGE CLASS 190	-	4.00	6.00	6.00							
AGE CLASS 200	-	4.00	4.00	6.00							
AGE CLASS 210	-	4.00	4.00	4.00							
AGE CLASS 220	-	4.00	4.00	4.00							
AGE CLASS 230	-	4.00	4.00	4.00							
AGE CLASS 240	-	12.00	4.00	4.00							
AGE CLASS 250	-	12.00	12.00	4.00							
AGE CLASS 260	-	12.00	12.00	12.00							
AGE CLASS 270	-	12.00	12.00	12.00							
AGE CLASS 280	-	12.00	12.00	12.00							
AGE CLASS 290	-		12.00	12.00							
AGE CLASS 300	-			12.00							
AGE CLASS 310	-	13.00	13.00	3.00							

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COMMERCIAL THINNING VOLUME (FT.) FOR STANDS THAT HAVE BEEN PRECOMMERCIALLY THINNED

* * * * * * * * * * * * THINNING NUMBER (FIRST THINNING BEGINS AT AGE 30) * * * * * * * * * * *

DECADE	-	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1ST	-										
2ND	-	900									
3RD	-	800	1100								
4TH	-	800	1050	1000							
5TH	-	800	1050	950	900						
6TH	-	800	1050	950	900	900					
7TH	-	800	1050	950	900	900					

COMMERCIAL THINNING VOLUME (FT.) FOR STANDS FIRST THINNED AT AGE 30

* THINNING NUMBER *

DECADE	-	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1ST	-	1000									
2ND	-		900								
3RD	-			1000							
4TH	-				900						
5TH	-					800					
6TH	-										
7TH	-										

COMMERCIAL THINNING VOLUME (FT.) FOR STANDS FIRST THINNED AT AGE 40

* * * * * * * * * * * * * * * * THINNING NUMBER * * * * * * * * * * * * * * * *

DECADE	-	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-
1ST	-	9000								
2ND	-		11000							
3RD	-			10000						
4TH	-				7000					
5TH	-									
6TH	-									
7TH	-									

COMMERCIAL THINNING VOLUME (FT.) FOR STANDS FIRST THINNED AT AGE 50

* * * * * * * * THINNING NUMBER * * * * * * * *

COMMERCIAL THINNING VOLUME (FT.) FOR STANDS FIRST THINNED AT AGE 60

* * * * THINNING NUMBER * * * *

C.T. VOLUME (FT.) FOR STANDS FIRST THINNED AT AGE 70

THINNING NUMBER

DECADE	-	-1-	-2-	-3-	-4-	-5-	-6-	-1-	-2-	-3-	-4-	-1-	-2-
1ST	-	11000						14000				18000	
2ND	-		13000						16000				
3RD	-			10000									
4TH	-												
5TH	-												
6TH	-												
7TH	-												

If no mortality salvage percent data are read, this page will not appear in the printout.

MORTALITY SALVAGE VOLUME (FT.)

AGE CLASS	-	1ST DECADE	2ND DECADE	3RD DECADE	4TH DECADE	5TH DECADE	6TH DECADE	7TH DECADE
80	-	7000	5500	4000	4000	4000	4000	4000
90	-	7000	5500	4000	4000	4000	4000	4000
100	-	7000	5500	4000	4000	4000	4000	4000
110	-	7000	5500	4000	4000	4000	4000	4000
120	-	7000	5500	4000	4000	4000	4000	4000
130	-	7000	5000	2500				
140	-	7000	5000	2500				
150	-	7000	5000	2500				
160	-	7000	5000	2500				
170	-	7000	5000	2500				
180	-	6000	6000	2500				
190	-	6000	6000	2500				
200	-	6000	6000	2500				
210	-	6000	6000	2500				
220	-	6000	6000	2500				
230	-	7000	6000	2500				
240	-	7000	6000	2500				
250	-	7000	6000	2500				
260	-	7000	6000	2500				
270	-	7000	6000	2500				
280	-		6000	2500				
290	-			2500				
300	-	8000	6000	2500				
310	-		6000	2500				
320	-			2500				
330	-							
340	-							
350	-							
360	-							
370	-							
380	-							
390	-							

INITIAL ACREAGE BY AGE CLASS AND TYPE

AGE CLASS	-	NON-TREATED	MORTALITY SALVAGE	FOREST GENETICS	THINNED	AGE FIRST THINNED
N/S	-	20000				
1-5	-	20000				
10	-	40000				
20	-	30000				
30	-	30000				
40	-	15000				
50	-	15000				
60	-	15000				
70	-	20000				
80	-	30000				
90	-	25000				
100	-	10000				
110	-	15000				
120	-	10000				
130	-	5000				
140	-	5000				
150	-	1000				
160	-	1000				
170	-	500				
180	-	1000				
190	-	500				
200	-	2000				
210	-	500				
220	-	1000				
230	-	500				
240	-	500				
250	-					
260	-	2500				
270	-	1000				
280	-	1000				
290	-	2000				
300	-	27000				

Blanks on the nontreated yield factor cards and the mortality yield factor cards are changed to 1.000 by SIMAC.

PROJECTION OF PRESENT YIELDS & GROWTH FOR NONTREATED STANDS AT THE BEGINNING OF THE FIRST TEN DECADES
-NONTREATED YIELD FACTORS-

STAND AGE	-	1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH
20	-	1.000	.800	.700	.600	.550	.500	.450	.400	.350	.300
30	-	1.000	.950	.850	.800	.700	.650	.600	.550	.500	.450
40	-	1.000	.950	.900	.900	.850	.800	.800	.750	.700	.700
50	-	1.000	1.000	1.000	.950	.950	.950	.900	.900	.900	.900
60	-	1.000	1.000	1.010	1.010	1.010	1.015	1.015	1.020	1.025	1.030
70	-	1.000	1.010	1.020	1.040	1.050	1.060	1.080	1.090	1.100	1.110
80	-	1.000	1.020	1.030	1.050	1.070	1.090	1.100	1.120	1.140	1.140
90	-	1.000	1.020	1.030	1.050	1.070	1.090	1.100	1.120	1.140	1.140
100	-	1.000	1.015	1.030	1.040	1.060	1.080	1.090	1.100	1.120	1.120
110	-	1.000	1.015	1.020	1.040	1.050	1.060	1.080	1.090	1.100	1.100
120	-	1.000	1.010	1.020	1.040	1.050	1.060	1.080	1.090	1.100	1.100
130	-	1.000	1.010	1.020	1.040	1.050	1.060	1.080	1.090	1.100	1.100

PROJECTION OF PRESENT YIELDS AND GROWTHS FOR MORTALITY SALVAGE STANDS AT THE BEGINNING OF THE FIRST TEN DECADES
-MORTALITY SALVAGE YIELD FACTORS-

STAND AGE	-	1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH	9TH	10TH
80	-	1.000	1.020	1.030	1.050	1.070	1.090	1.100	1.120	1.140	1.140
90	-	1.000	1.020	1.030	1.050	1.070	1.090	1.100	1.120	1.140	1.140
100	-	1.000	1.020	1.030	1.040	1.060	1.080	1.090	1.100	1.120	1.120
110	-	1.000	1.010	1.020	1.040	1.050	1.060	1.080	1.090	1.100	1.100
120	-	1.000	1.010	1.020	1.040	1.050	1.060	1.080	1.090	1.100	1.100
130	-	1.000	1.010	1.020	1.040	1.050	1.050	1.080	1.090	1.100	1.100

PERCENT OF TOTAL FINAL HARVEST VOLUME TO BE CUT FROM EACH AGE CLASS

AGE CLASS	-	PERCENT	AGE CLASS	-	PERCENT
30	-		270	-	1.0
40	-		280	-	2.0
50	-		290	-	2.0
60	-		300	-	2.0
70	-		310	-	2.0
80	-	8.0	320	-	2.0
90	-	8.0	330	-	
100	-	8.0	340	-	
110	-	8.0	350	-	27.0
120	-	8.0	360	-	
130	-	2.4	370	-	
140	-	2.4	380	-	
150	-	2.4	390	-	
160	-	2.4	400	-	
170	-	2.4	410	-	
180	-	1.2	420	-	
190	-	1.2	430	-	
200	-	1.2	440	-	
210	-	1.2	450	-	
220	-	1.2	460	-	
230	-	1.0	470	-	
240	-	1.0	480	-	
250	-	1.0	490	-	
260	-	1.0	500	-	

2. *Initial Inventory*

The initial inventory is listed immediately after the "Basic Data" output section in a five-column table with these column headings:

a. Age class
b. Treatment class
c. Acres
d. Total volume
e. Annual growth

The initial inventory output statement for the sample problem will serve as a sample of the second section of the printed output.

SAMPLE PROB. 09/20/72 PAGE 11

* * * A L L O W A B L E C U T C O M P U T A T I O N S * * *

* * OVERFLOW * *

YEAR 197[illegible]					INITIAL TEST LEVEL							
					VOLUME CUT M FT.			ACRES HARVESTED				
AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
N/S	NON-TREATED	2000.0										
1-5	NON-TREATED	2000.0										
10	NON-TREATED	4000.0										
20	NON-TREATED	3000.0										
30	NON-TREATED	3000.0	489865	23496521								
40	NON-TREATED	1500.0	359352	11139007								
50	NON-TREATED	1500.0	467645	10522953								
60	NON-TREATED	1500.0	369811	9910299								
70	NON-TREATED	2000.0	897801	12396860								
80	NON-TREATED	3000.0	1511529	17369982								
90	NON-TREATED	2500.0	1399251	13457895								
100	NON-TREATED	1000.0	611474	4973122								
110	NON-TREATED	1500.0	998744	6847029								
120	NON-TREATED	1000.0	702768	4156250								
130	NON-TREATED	500.0	371144	1873907								
140	NON-TREATED	500.0	388962	1669689								
150	NON-TREATED	100.0	40304	293094								

*** ALLOWABLE CUT COMPUTATIONS ***

* * EVENFLOW * *

YEAR 1970					INITIAL TEST LEVEL							
					VOLUME CUT M FT.			ACRES HARVESTED				
AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
160	NON-TREATED	1000	83634	252251								
170	NON-TREATED	500	42976	105704								
180	NON-TREATED	1000	87862	170563								
190	NON-TREATED	500	44682	64860								
200	NON-TREATED	2000	180914	177753								
210	NON-TREATED	500	45571	24016								
220	NON-TREATED	1000	91417	7189								
230	NON-TREATED	500	45643	-16827								
240	NON-TREATED	500	45372	-37249								
260	NON-TREATED	2500	221094	-390463								
270	NON-TREATED	1000	86671	-197029								
280	NON-TREATED	1000	84497	-237873								
290	NON-TREATED	2000	163828	-557432								
300	NON-TREATED	27000	2130911	-8626112								
	INITIAL LEVEL	347000	12184226	109936559								

3. Decade Statement

The projected forest is described each decade in a printed output table. The first column of the table gives each stand's age at the beginning of the decade. The next four columns relate to the structure of the stands at the end of the decade. The last eight columns describe what occurred during the decade. Listed by age class and treatment are the number of acres treated and the volume realized from the application of that treatment. The ingrowth listed at the end of each decade table is the volume in the 20-year age class at age 25 years.

Following are the first two decades and the last two decades of a 40-year projection period using the sample data.

Output table for decade 1

SAMPLE PROB. ALLOWABLE CUT COMPUTATIONS 10/20/72 2940000 M. 80.FT. INT 1/8" DECADE CUT PAGE 13

* * EVENFLOW * *

1971 ---YEAR 1980---					VOLUME CUT M FT. (1971 - 1980)			ACRES HARVESTED (1971 - 1980)				
AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
N/S	NON-TREATED	20000										
1-5	NON-TREATED	20000										
10	NON-TREATED	35200										
10	PC & C THIN	4800							4800			
	CLASS TOTAL	40000							4800			
20	NON-TREATED	18000	279223	11928016								
20	PC & C THIN	12000	159760	11017560					12000			
	CLASS TOTAL	30000	438983	22945576					12000			
30	NON-TREATED	22500	512077	16285825								
30	C THIN 30-70	7500	163032	6500475	7500					7500		
	CLASS TOTAL	30000	675109	22786300	7500					7500		
40	NON-TREATED	12300	383469	8841814								
40	C THIN 40-70	2700	77349	4091391	24300					2700		
	CLASS TOTAL	15000	460818	12933205	24300					2700		
50	NON-TREATED	12750	484339	8949561								
50	C THIN 50-70	2250	89698	3960000	24750					2250		
	CLASS TOTAL	15000	574037	12909561	24750					2250		
60	NON-TREATED	12000	538007	8329194								
60	C THIN 60-70	3000	129883	4277143	42000					3000		
	CLASS TOTAL	15000	667890	12606337	42000					3000		
70	NON-TREATED	13000	668095	8640212								
70	C THIN 70	7000	428320	24000001	126000					7000		
	CLASS TOTAL	20000	1096415	32640213	126000					7000		
80	NON-TREATED	25099	1432888	15848814			215096					4001
80	MORT. SALV.	900	48937	1158891		6300					900	
	CLASS TOTAL	25999	1481825	17007705		6300	215096				900	4001

SAMPLE PROB. ALLOWABLE CUT COMPUTATIONS 10/20/72 2940000 M. 80.FT. INT 1/8" DECADE CUT PAGE 14

* * EVENFLOW * *

1971 ---YEAR 1980---					VOLUME CUT M FT. (1971 - 1980)			ACRES HARVESTED (1971 - 1980)				
AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
90	NON-TREATED	20607	1278965	11635226			215117					3643
90	MORT. SALV.	750	44600	939198		5250					750	
	CLASS TOTAL	21357	1323565	12574424		5250	215117				750	3643
100	NON-TREATED	6343	424379	3349356			215049					3357
100	MORT. SALV.	300	19059	364283		2100					300	
	CLASS TOTAL	6643	443438	3713639		2100	215049				300	3357
110	NON-TREATED	11409	809805	5590490			215122					3141
110	MORT. SALV.	450	30501	544871		3150					450	
	CLASS TOTAL	11859	840306	6135361		3150	215122				450	3141
120	NON-TREATED	6740	505305	2538657			215089					2960
120	MORT. SALV.	300	21490	309325		2100					300	
	CLASS TOTAL	7040	526795	2847982		2100	215089				300	2960
130	NON-TREATED	4002	311245	1336419			64492					848
130	MORT. SALV.	150	11152	147967		1050					150	
	CLASS TOTAL	4152	322397	1484386		1050	64492				150	848
140	NON-TREATED	3887	314488	1139257			64545					813
140	MORT. SALV.	300	23214	295074		2100					300	
	CLASS TOTAL	4187	337702	1434332		2100	64545				300	813
150	NON-TREATED	147	12294	37081			65281					793
150	MORT. SALV.	60	4801	56662		420					60	
	CLASS TOTAL	207	17095	93743		420	65281				60	793
160	NON-TREATED						84844					1000
170	NON-TREATED						43479					500
180	NON-TREATED	576	51474	74719			32274					364
180	MORT. SALV.	60	5135	43605		360					60	
	CLASS TOTAL	636	56609	118323		360	32274				60	364

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

1971 ---- YEAR 1980 ----					---- 1971 - 1980 ---- VOLUME CUT M FT.			ACRES HARVESTED				
AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
190	NON-TREATED	122	11036	10843			32266					358
190	MORT. SALV.	20	1733	13751		120					20	
	CLASS TOTAL	142	12769	24594		120	32266				20	358
200	NON-TREATED	1565	142636	75171			32252					355
200	MORT. SALV.	80	6987	51866		480					80	
	CLASS TOTAL	1645	149623	127037		480	32252				80	355
210	NON-TREATED	126	11519	906			32331					354
210	MORT. SALV.	20	1753	12182		120					20	
	CLASS TOTAL	146	13271	13088		120	32331				20	354
220	NON-TREATED	607	55410	-20428			32265					353
220	MORT. SALV.	40	3501	22796		240					40	
	CLASS TOTAL	647	58911	2368		240	32265				40	353
230	NON-TREATED	91	9258	-6779			35425					389
230	MORT. SALV.	20	1740	12614		140					20	
	CLASS TOTAL	111	9998	5835		140	35425				20	389
240	NON-TREATED						45160					500
260	NON-TREATED	1893	164069	-372976			26895					307
260	MORT. SALV.	300	24954	153923		2100					300	
	CLASS TOTAL	2193	189023	-219052		2100	26895				300	307
270	NON-TREATED	566	47825	-134636			26889					314
270	MORT. SALV.	120	9734	56864		840					120	
	CLASS TOTAL	686	57559	-77772		840	26889				120	314
280	NON-TREATED	234	19168	-65220			53784					646
280	MORT. SALV.	120	9439	-31841							120	
	CLASS TOTAL	354	28607	-97060			53784				120	646

ALLOWABLE CUT COMPUTATIONS 2940[illegible] M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

1971 ---- YEAR 1980 ----					---- 1971 - 1980 ---- VOLUME CUT M FT.			ACRES HARVESTED				
AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
290	NON-TREATED	1332	115125	-425654			53754					668
300	NON-TREATED	15518	1171963	-5592739			867258					11480
DECADE	1 TOTALS	359[illegible]4	11059836	135991734	224550	26870	2088026		16800	22450	3990	37146
ACRES CLEAR CUT		37146	INGROWTH	31934878	PARTIAL CUT VOLUME		251420					
TOTAL ACREAGE		347[illegible]	AN GRWTH	187926612	TOTAL DECADE VOLUME		2940026					

Output table for decade 2

SAMPLE PROB. 09/20/72 PAGE 17

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

1981	-----YEAR 1990-----				VOLUME CUT M FT. 1981 - 1990			ACRES HARVESTED 1981 - 1990				
AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
N/S	NON-TREATED	10311										
1-5	NON-TREATED	17186										
10	NON-TREATED	31405										
10	FOREST GEN.	11719						11719				
10	PC & C THIN	3750							3750			
	CLASS TOTAL	46874						11719	3750			
20	NON-TREATED	30000	416386	22413713								
20	PC & C THIN	10000	133133	9181300					5200			
	CLASS TOTAL	40000	549519	31595013					5200			
30	NON-TREATED	18000	398100	12360524								
30	PC & C THIN	12000	260851	18800760	96000					12000		
	CLASS TOTAL	30000	648951	31161284	96000					12000		
40	NON-TREATED	22500	701467	17727541								
40	C THIN 30-70	7500	214859	11364975	67500					7500		
	CLASS TOTAL	30000	916327	29092516	67500					7500		
50	NON-TREATED	8700	333795	6494286								
50	C THIN 40-70	6300	214478	9852759	69300					6300		
	CLASS TOTAL	15000	548274	16347045	69300					6300		
60	NON-TREATED	11250	509376	8377166								
60	C THIN 50-70	3750	162354	4971428	48750					3750		
	CLASS TOTAL	15000	671729	13348594	48750					3750		
70	NON-TREATED	8250	428140	5750545								
70	C THIN 60-70	6750	358917	18276036	108000					6750		
	CLASS TOTAL	15000	787057	24026581	108000					6750		

SAMPLE PROB. 09/20/72 PAGE 18

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

1981	-----YEAR 1990-----				VOLUME CUT M FT. 1981 - 1990			ACRES HARVESTED 1981 - 1990				
AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
80	NON-TREATED	8516	490940	5196629			200995					3684
80	MORT. SALV.	800	43926	938693		4400					800	
80	C THIN 70	7400	518920	6720031								
	CLASS TOTAL	16716	1053786	12855323		4400	200995				800	3684
90	NON-TREATED	21613	1361226	12391336			201011					3346
90	MORT. SALV.	1040	62452	1151343		5720					1040	
	CLASS TOTAL	22653	1423677	13542679		5720	201011				1040	3346
100	NON-TREATED	17396	1169513	9561560			201009					3107
100	MORT. SALV.	854	54792	914535		4697					854	
	CLASS TOTAL	18250	1224305	10476094		4697	201009				854	3107
110	NON-TREATED	3444	246974	1767730			201017					2899
110	MORT. SALV.	300	20335	320053		1650					300	
	CLASS TOTAL	3744	267309	2087783		1650	201017				300	2899
120	NON-TREATED	8646	654618	2930194			201011					2739
120	MORT. SALV.	474	34291	432982		2607					474	
	CLASS TOTAL	9120	688909	3363176		2607	201011				474	2739
130	NON-TREATED	5951	462823	1760972			60305					789
130	MORT. SALV.	300	22305	225031		1500					300	
	CLASS TOTAL	6251	485128	1986003		1500	60305				300	789
140	NON-TREATED	3185	257691	933505			60258					759
140	MORT. SALV.	208	16095	162985		1040					208	
	CLASS TOTAL	3393	273786	1096490		1040	60258				208	759
150	NON-TREATED	1534	128295	386952			193704					2353
150	MORT. SALV.	300	24036	223312		1500					300	
	CLASS TOTAL	1834	152331	610264		1500	193704				300	2353

SAMPLE PROB. ALLOWABLE CUT COMPUTATIONS 09/20/72 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

1981 ----YEAR 1990---- ---- 1981 - 1990 ----

AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	VOLUME CUT M FT. COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	ACRES HARVESTED FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
160	NON-TREATED						12472					147
160	MORT. SALV.						4872					60
	CLASS TOTAL						17344					207
190	NON-TREATED	48	4342	4266			47500					528
190	MORT. SALV.	60	5200	41252		360					60	
	CLASS TOTAL	108	9541	45518		360	47500				60	528
200	NON-TREATED						11084					122
200	MORT. SALV.						1741					20
	CLASS TOTAL						12825					142
210	NON-TREATED	702	64175	5047			78818					863
210	MORT. SALV.	80	7010	48730		480					80	
	CLASS TOTAL	782	71185	53776		480	78818				80	863
220	NON-TREATED						11517					126
220	MORT. SALV.						1752					20
	CLASS TOTAL						13269					146
230	NON-TREATED						55277					607
230	MORT. SALV.						3493					40
	CLASS TOTAL						58770					647
240	NON-TREATED						8219					91
240	MORT. SALV.						1733					20
	CLASS TOTAL						9952					111
270	NON-TREATED	1416	119648	-336827			40848					477
270	MORT. SALV.	300	24335	112161		1800					300	
	CLASS TOTAL	1716	143982	-224667		1800	40848				300	477
280	NON-TREATED						47123					566
280	MORT. SALV.						9592					120
	CLASS TOTAL						56715					686

SAMPLE PROB. ALLOWABLE CUT COMPUTATIONS 09/20/72 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

1981 ----YEAR 1990---- ---- 1981 - 1990 ----

AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	VOLUME CUT M FT. COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	ACRES HARVESTED FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
290	NON-TREATED						18830					234
290	MORT. SALV.						9274					120
	CLASS TOTAL						28104					354
300	NON-TREATED	682	51507	-245795			50228					650
310	NON-TREATED	2928	209980	-1174851			778910					1573
310	MORT. SALV.	2017	139038	437760		12102					2017	
	CLASS TOTAL	4945	349018	-737091		12102	778910				2017	1573
DECADE 2 TOTALS		309165	10316492	190482586	389550	37850	2512592	11719	8950	36300	6733	[illegible]
ACRES CLEAR CUT		35060	INGROWTH	39128628	PARTIAL CUT VOLUME		427406					
TOTAL ACREAGE		344225	AN GRWTH	22961121-	TOTAL DECADE VOLUME		2939998					

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

2351 ----------------YEAR 2360---------------- -------------------------------- 2351 - 2360 --------------------------------

AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	VOLUME CUT M FT. COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	ACRES HARVESTED FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
N/S	NON-TREATED	12713										
1-5	NON-TREATED	21188										
10	NON-TREATED	7189										
10	FOREST GEN.	31717						31717				
10	PC & C THIN	3383							3383			
	CLASS TOTAL	42289						31717	3383			
20	FOREST GEN.	31635	240681	44805392								
20	PC & C THIN	10545	140389	9681681					7171			
	CLASS TOTAL	42180	381070	54487073					7171			
30	FOREST GEN.	31553	667605	40820439								
30	PC & C THIN	10517	228614	16477299	84136					10517		
	CLASS TOTAL	42070	896220	57297739	84136					10517		
40	FOREST GEN.	31468	1053620	36852082								
40	PC & C THIN	10489	300488	17467646	110134					10489		
	CLASS TOTAL	41957	1354108	54319729	110134					10489		
50	FOREST GEN.	31384	1399104	32905618								
50	PC & C THIN	10461	356136	14791122	99379					10461		
	CLASS TOTAL	41845	1755240	47696740	99379					10461		
60	FOREST GEN.	31300	1704346	28979752								
60	PC & C THIN	10433	395687	12650325	93897					10433		
	CLASS TOTAL	41733	2100033	41630078	93897					10433		
70	FOREST GEN.	1897	119696	1523779			1727593					29317
70	PC & C THIN	10434	478563	23323421	93636					10404		
	CLASS TOTAL	12331	598259	24847200	93636		1727593			10404		29317

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

2351 ----------------YEAR 2360---------------- -------------------------------- 2351 - 2360 --------------------------------

AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	VOLUME CUT M FT. COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	ACRES HARVESTED FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
80	FOREST GEN.						186753					2789
80	PC & C THIN						544485					10375
	CLASS TOTAL						731239					13164
DECADE 39 TOTALS		298276	7084929	280278558	481183		2458831	31717	10554	52304		42481
ACRES CLEAR CUT		42481	INGROWTH	10178993	PARTIAL CUT VOLUME		481183					
TOTAL ACREAGE		340757	AN GRWTH	290457551	TOTAL DECADE VOLUME		2940014					

Output table for decade 40

SAMPLE PROB. 09/20/72 PAGE 97

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

2361 ----YEAR 2370---- ---- 2361 - 2370 ----

AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	VOLUME CUT M FT. COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	ACRES HARVESTED FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
N/S	NON-TREATED	12744										
1-5	NON-TREATED	21241										
10	NON-TREATED	7207										
10	FOREST GEN.	31798						31798				
10	PC & C THIN	3392							3392			
	CLASS TOTAL	42397						31798	3392			
20	FOREST GEN.	31717	241305	44921530								
20	PC & C THIN	10572	140748	9706470					7189			
	CLASS TOTAL	42289	392053	54628001					7189			
30	FOREST GEN.	31635	669340	40926524								
30	PC & C THIN	10545	229223	16521168	84360					10545		
	CLASS TOTAL	42180	898563	57447692	84360					10545		
40	FOREST GEN.	31553	1056466	36951626								
40	PC & C THIN	10517	301290	17514276	110428					10517		
	CLASS TOTAL	42070	1357756	54465901	110428					10517		
50	FOREST GEN.	31468	1402849	32993690								
50	PC & C THIN	10489	357090	14830712	99645					10489		
	CLASS TOTAL	41957	1759938	47824402	99645					10489		
60	FOREST GEN.	31384	1708920	29057526								
60	PC & C THIN	10461	396749	12684276	94149					10461		
	CLASS TOTAL	41845	2105669	41741802	94149					10461		
70	FOREST GEN.	1017	64170	816913			1784517					30283
70	PC & C THIN	10433	479897	23388432	93897					10433		
	CLASS TOTAL	11450	544067	24205345	93897		1784517			10433		30283

SAMPLE PROB. 09/20/72 PAGE 98

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

2361 ----YEAR 2370---- ---- 2361 - 2370 ----

AGE CLASS	TREATMENT CLASS	ACRES	TOTAL VOL M FT.	ANNUAL GROWTH FT.	VOLUME CUT M FT. COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	ACRES HARVESTED FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
80	FOREST GEN.						127024					1897
80	PC & C THIN						546007					10404
	CLASS TOTAL						673032					12301
DECADE 40 TOTALS		298173	7048046	280313143	482480		2457549	31798	10581	52445		42584

ACRES CLEAR CUT	42584	INGROWTH	10205093	PARTIAL CUT VOLUME	482480
TOTAL ACREAGE	340757	AN GRWTH	290518236	TOTAL DECADE VOLUME	2940029

4. *Trial Cut Summary by Decade*

Included for each decade are totals for forest acreage, standing volume at the end of the decade, average annual growth at the end of the decade, volume from commercial thinning, volume from mortality salvage, volume from final harvest cut, acres to undergo forest genetic improvement, acres precommercially thinned, acres commercially thinned, acres that underwent mortality salvage, and acres of harvest cut. On the second line of each decade summary are the change in total standing volume from the previous decade, the change in average annual growth from the previous decade, and the percent of the total volume harvested that was contributed during the decade by commercial thinning, mortality salvage, and harvest cutting. The trial cut summary by decade for the sample problem follows.

SAMPLE PROB. 03/22/72 PAGE 99

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

DECADE SUMMARIES

DECADE	ACRES	TOTAL VOL MFT.	GROWTH FT.	VOLUME CUT MFT. COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	ACRES FOREST GENETICS	P. COMM. THINNING	HARVESTED COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
INITIAL LEVL	347000	12194226	108836559								
1 DECADE TOTAL	347000	11059836	187926612	224550	26870	2088606		16800	22450	3990	37146
		-1124390	79090053	7.6 %	.9 %	91.4 %					
2 DECADE TOTAL	344225	10316492	229611214	385550	37855	2512592	11719	8950	36300	6733	35060
		-743344	+41684602	13.3 %	1.3 %	85.5 %					
3 DECADE TOTAL	341103	9736096	248820569	387500	15711	2536799	25414	10680	39550	4218	35207
		-580396	19209355	13.2 %	.5 %	86.3 %					
4 DECADE TOTAL	339369	9200080	251466218	430352	14376	2495258	24184	8340	47519	3594	34521
		-536016	2645649	14.6 %	.5 %	84.9 %					
5 DECADE TOTAL	340063	8893080	268880451	453818	3600	2482620	25366	8187	49690	900	34259
		-307000	17414233	15.4 %	.1 %	84.4 %					
6 DECADE TOTAL	340410	8742476	289985726	462704	3600	2473679	26320	8556	50251	900	36608
		-150604	21105275	15.7 %	.1 %	84.1 %					
7 DECADE TOTAL	340757	8684952	289291811	428226	3600	2508190	26307	8772	46706	900	40340
		-57524	-693915	14.6 %	.1 %	85.3 %					
8 DECADE TOTAL	340757	8603710	283171376	417251		2522763	28224	8974	45479		41033
		-81242	-6120435	14.2 %		85.8 %					
9 DECADE TOTAL	340757	8451963	279563799	391370		2548651	30359	8635	42529		40720
		-151747	-3607577	13.3 %		86.7 %					
10 DECADE TOTAL	340757	8337182	284340776	399326		2540704	30728	10159	43466		37708
		-114781	4776977	13.6 %		86.4 %					

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

DECADE SUMMARIES

DECADE		ACRES	TOTAL VOL MFT.	GROWTH FT.	VOLUME CUT M FT. COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	ACRES HARVESTED FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
11	DECADE TOTAL	340757	8285973	291694113	418102		2521982	30059	10173	45505		37346
			-51209	7353337	14.2 %		85.8 %					
12	DECADE TOTAL	340757	8285544	295070921	435450		2504574	28226	9831	47312		38133
			-429	3376808	14.8 %		85.2 %					
13	DECADE TOTAL	340757	8281531	292025251	447506		2492481	28128	9398	48568		38961
			-4013	-3045670	15.2 %		84.8 %					
14	DECADE TOTAL	340757	8249749	289565227	453628		2486395	28724	9440	49208		39463
			-31782	-2460024	15.4 %		84.6 %					
15	DECADE TOTAL	340757	8197993	288533091	452336		2487635	29288	9634	49176		39731
			-51756	-1032136	15.4 %		84.6 %					
16	DECADE TOTAL	340757	8136059	287955053	446865		2493115	29601	9735	49600		39847
			-61934	-578038	15.2 %		84.8 %					
17	DECADE TOTAL	340757	8071398	287928336	442637		2497375	29823	9841	48150		39853
			-64661	-26717	15.1 %		84.9 %					
18	DECADE TOTAL	340757	8008974	288081176	441435		2498522	29917	9951	47985		39754
			-62424	152840	15.0 %		85.0 %					
19	DECADE TOTAL	340757	7954508	288941669	446421		2493597	29874	9968	48500		39841
			-54466	860493	15.2 %		84.8 %					
20	DECADE TOTAL	340757	7907206	289516446	451917		2488089	29846	9967	49116		40058
			-47302	574777	15.4 %		84.6 %					
21	DECADE TOTAL	340757	7862018	289574859	455487		2484521	29914	9956	49500		40286
			-45188	58413	15.5 %		84.5 %					
22	DECADE TOTAL	340757	7815270	289370500	457178		2482431	[illegible]	9988	[illegible]		40472
			-46748	-204359	15.6 %		84.4 %					

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

DECADE SUMMARIES

DECADE		ACRES	TOTAL VOL MFT.	GROWTH FT.	VOLUME CUT M FT. COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST	ACRES HARVESTED FOREST GENETICS	P. COMM. THINNING	COMM. THINNING	MORTALITY SALVAGE	FINAL HARVEST
23	DECADE TOTAL	340757	7766717	289257826	456070		2481308	30240	10044	44793		40614
			-48553	-112674	15.6 %		84.4 %					
24	DECADE TOTAL	340757	7717534	289267953	458807		2481217	30377	10045	[illegible]		[illegible]
			-49183	10127	15.6 %		84.4 %					
25	DECADE TOTAL	340757	7668973	289355016	459827		2480163	[illegible]	[illegible]	[illegible]		[illegible]
			-48561	87063	15.6 %		84.4 %					
26	DECADE TOTAL	340757	7621766	289489120	461378		2478596	[illegible]	[illegible]	[illegible]		[illegible]
			-47207	134104	15.7 %		84.3 %					
27	DECADE TOTAL	340757	7576123	289639700	463343		2470077	30652	[illegible]	50364		[illegible]
			-45643	150580	15.8 %		84.2 %					
28	DECADE TOTAL	340757	7531866	289759765	465369		2474605	30736	10205	50584		[illegible]
			-44257	120065	15.8 %		84.2 %					
29	DECADE TOTAL	340757	7488395	289826858	467125		2472358	[illegible]	[illegible]	[illegible]		[illegible]
			-43471	67093	15.9 %		84.1 %					
30	DECADE TOTAL	340757	7445306	289865740	468627		2471377	[illegible]	10287	[illegible]		[illegible]
			-43089	38882	15.9 %		84.1 %					
31	DECADE TOTAL	340757	7402591	289912527	470010		2469996	[illegible]	10321	[illegible]		[illegible]
			-42715	46787	16.0 %		84.0 %					
32	DECADE TOTAL	340757	7360438	289976587	471378		2468064	[illegible]	10353	[illegible]		[illegible]
			-42153	64060	16.0 %		84.0 %					
33	DECADE TOTAL	340757	7318953	290050173	472779		2467230	31214	10384	51351		[illegible]
			-41485	73586	16.1 %		83.9 %					
34	DECADE TOTAL	340757	7278217	290127941	474236		2465790	[illegible]	10414	51544		[illegible]
			-40736	77768	16.1 %		83.9 %					

SAMPLE PROB. 09/20/72 PAGE 102

ALLOWABLE CUT COMPUTATIONS 2940000 M. BD.FT. INT 1/8" DECADE CUT

* * EVENFLOW * *

DECADE SUMMARIES

DECADE	ACRES	TOTAL VOL MFT.	GROWTH FT.	VOLUME CUT M FT. COMM. THINNING	VOLUME CUT M FT. MORTALITY SALVAGE	VOLUME CUT M FT. FINAL HARVEST	ACRES HARVESTED FOREST GENETICS	ACRES HARVESTED P. COMM. THINNING	ACRES HARVESTED COMM. THINNING	ACRES HARVESTED MORTALITY SALVAGE	ACRES HARVESTED FINAL HARVEST
35 DECADE TOTAL	340757	7238249 -39968	290203864 75923	475702 16.2 %		2464321 83.8 %	31384	10442	51708		42047
36 DECADE TOTAL	340757	7199018 -39231	290274005 70141	477146 16.2 %		2462847 83.8 %	31468	10470	51865		42158
37 DECADE TOTAL	340757	7160421 -38597	290337016 63011	478535 16.3 %		2461455 83.7 %	31553	10498	52016		42268
38 DECADE TOTAL	340757	7122379 -38042	290398960 61944	479877 16.3 %		2460152 83.7 %	31635	10525	52162		42376
39 DECADE TOTAL	340757	7084929 -37450	290457551 58591	481183 16.4 %		2458831 83.6 %	31717	10554	52304		42481
40 DECADE TOTAL	340757	7048046 -36883	290518236 60685	482480 16.4 %		2457549 83.6 %	31798	10561	52445		42584

E. Data Processing Requirements

SIMAC is written in FORTRAN IV and runs on a CDC 6400 computer with a SCOPE 3.3 operating system. The SIMAC program should run on other computers with only minor program or control card modifications. FORTRAN statements that are not in common use were avoided in coding SIMAC.

The core requirement for the SIMAC object deck and system routines is just under 17,000 words, decimal (41,000 words, octal).

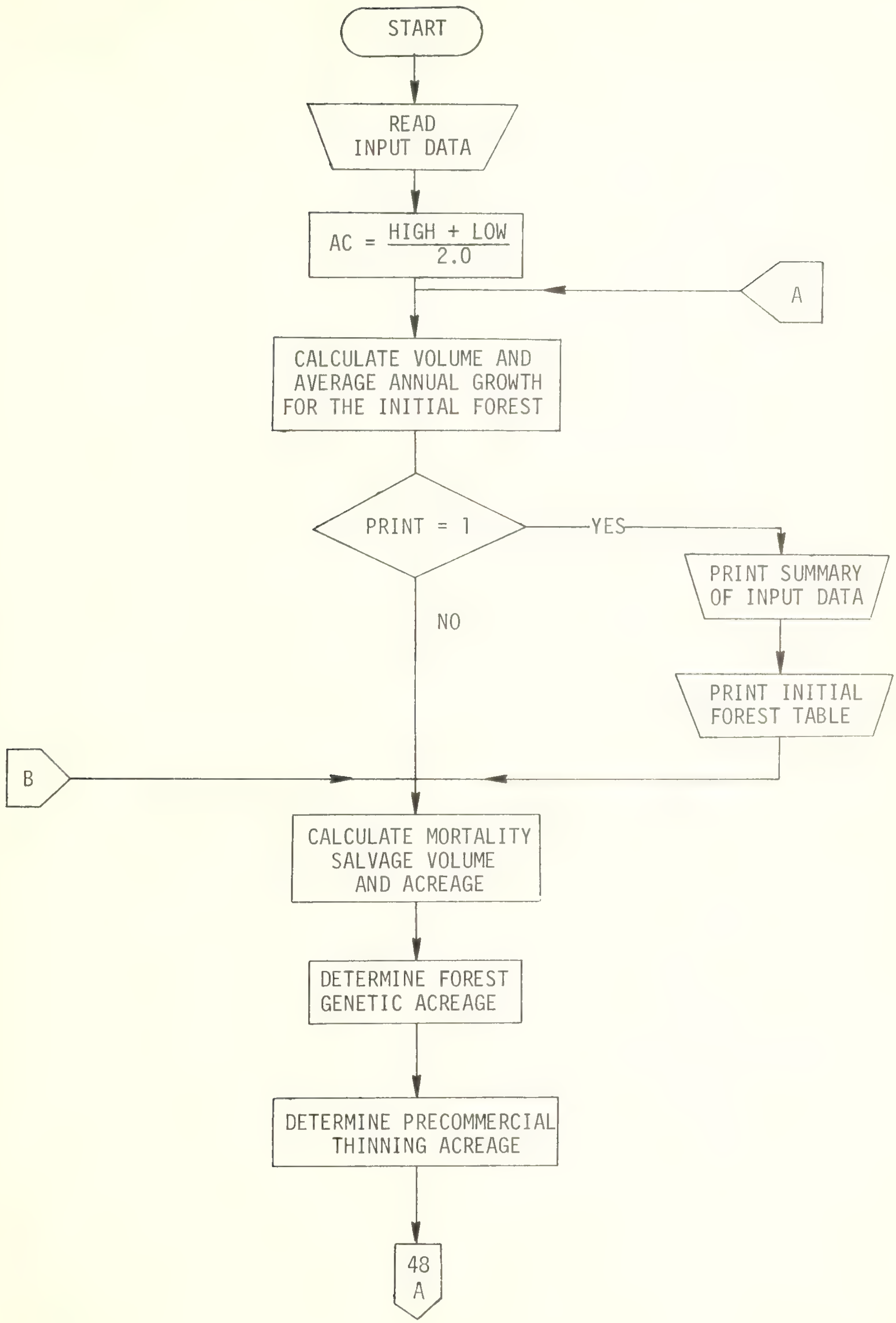
A typical SIMAC run on the CDC 6400, printing all the output for 40 decades for each of four tests, runs in less than 120 seconds. By printing only the highest sustainable level test for 40 decades, the time can be cut to less than 60 seconds.

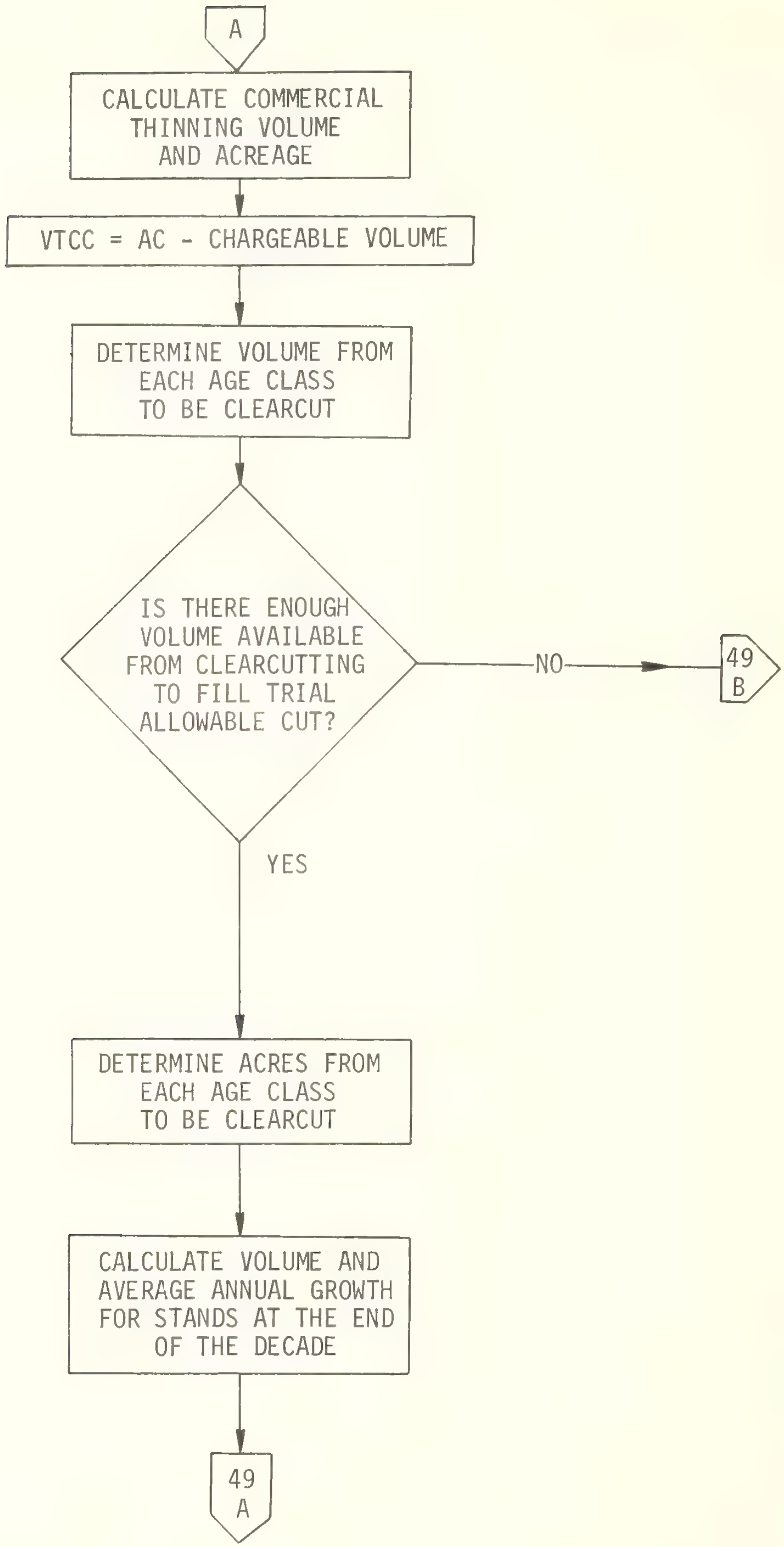
F. SIMAC FORTRAN IV Source Deck

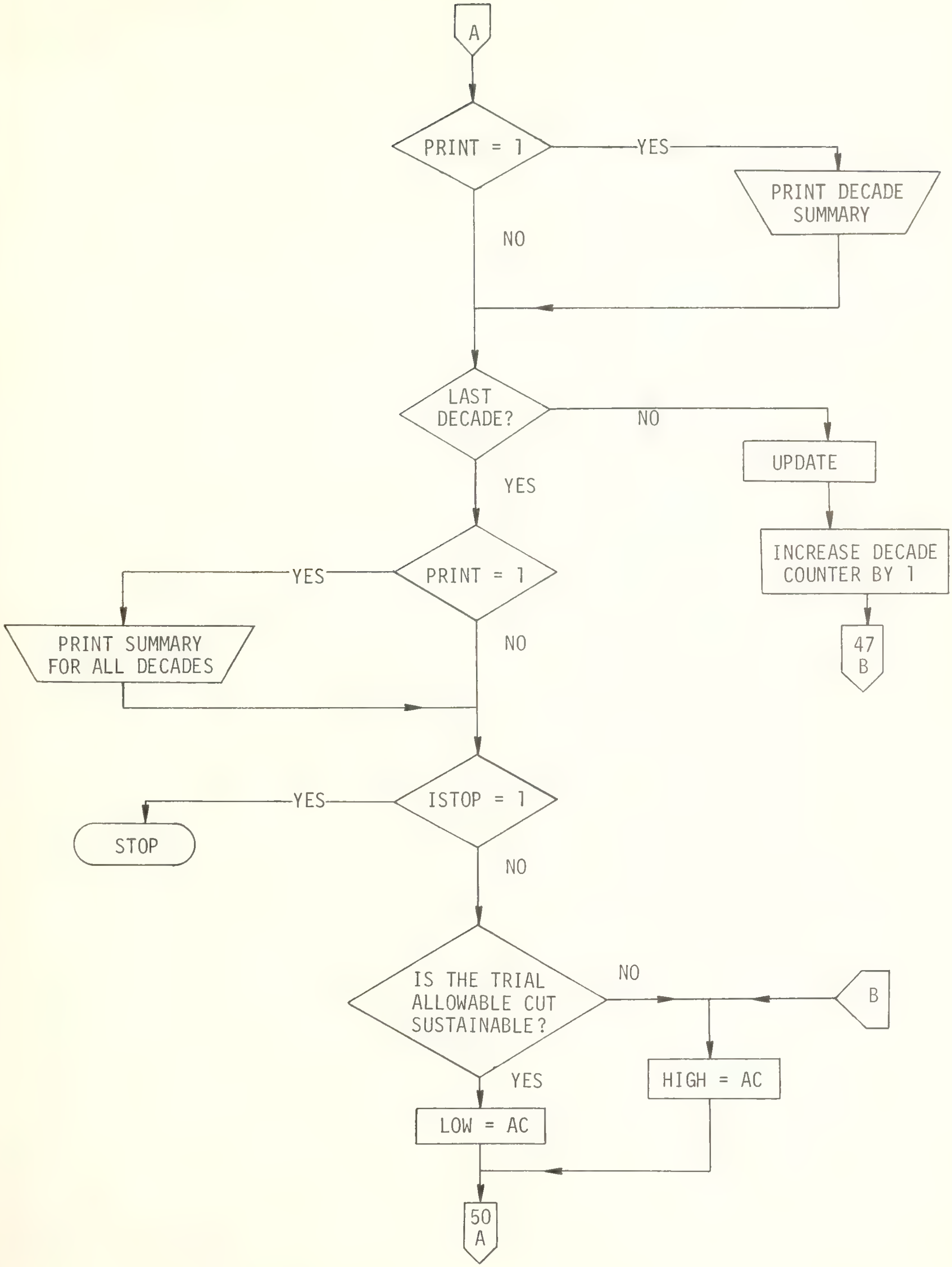
Requests for a FORTRAN IV source deck (approximately 2,000 cards) and a sample problem data deck may be addressed to the Director, Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, P.O. Box 3141, Portland, Oregon 97208.

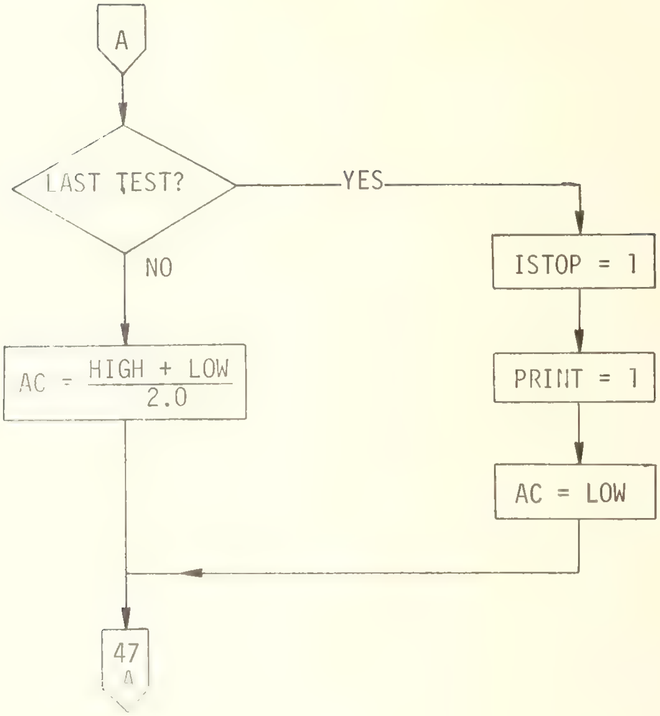
APPENDIX

SIMAC General Logic Flow Chart


START
READ INPUT DATA
AC = $\frac{\text{HIGH + LOW}}{2.0}$
A
CALCULATE VOLUME AND AVERAGE ANNUAL GROWTH FOR THE INITIAL FOREST
PRINT = 1
YES
NO
PRINT SUMMARY OF INPUT DATA
PRINT INITIAL FOREST TABLE
B
CALCULATE MORTALITY SALVAGE VOLUME AND ACREAGE
DETERMINE FOREST GENETIC ACREAGE
DETERMINE PRECOMMERCIAL THINNING ACREAGE
48
A


A
CALCULATE COMMERCIAL THINNING VOLUME AND ACREAGE
VTCC = AC - CHARGEABLE VOLUME
DETERMINE VOLUME FROM EACH AGE CLASS TO BE CLEARCUT
IS THERE ENOUGH VOLUME AVAILABLE FROM CLEARCUTTING TO FILL TRIAL ALLOWABLE CUT?
NO
49 B
YES
DETERMINE ACRES FROM EACH AGE CLASS TO BE CLEARCUT
CALCULATE VOLUME AND AVERAGE ANNUAL GROWTH FOR STANDS AT THE END OF THE DECADE
49 A


A
PRINT = 1
YES
PRINT DECADE SUMMARY
NO
LAST DECADE?
NO
UPDATE
YES
INCREASE DECADE COUNTER BY 1
47 B
YES
PRINT = 1
PRINT SUMMARY FOR ALL DECADES
NO
YES
ISTOP = 1
STOP
NO
IS THE TRIAL ALLOWABLE CUT SUSTAINABLE?
NO
B
YES
HIGH = AC
LOW = AC
50 A



GPO 796-676

The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Development and evaluation of alternative methods and levels of resource management.
3. Achievement of optimum sustained resource productivity consistent with maintaining a high quality forest environment.

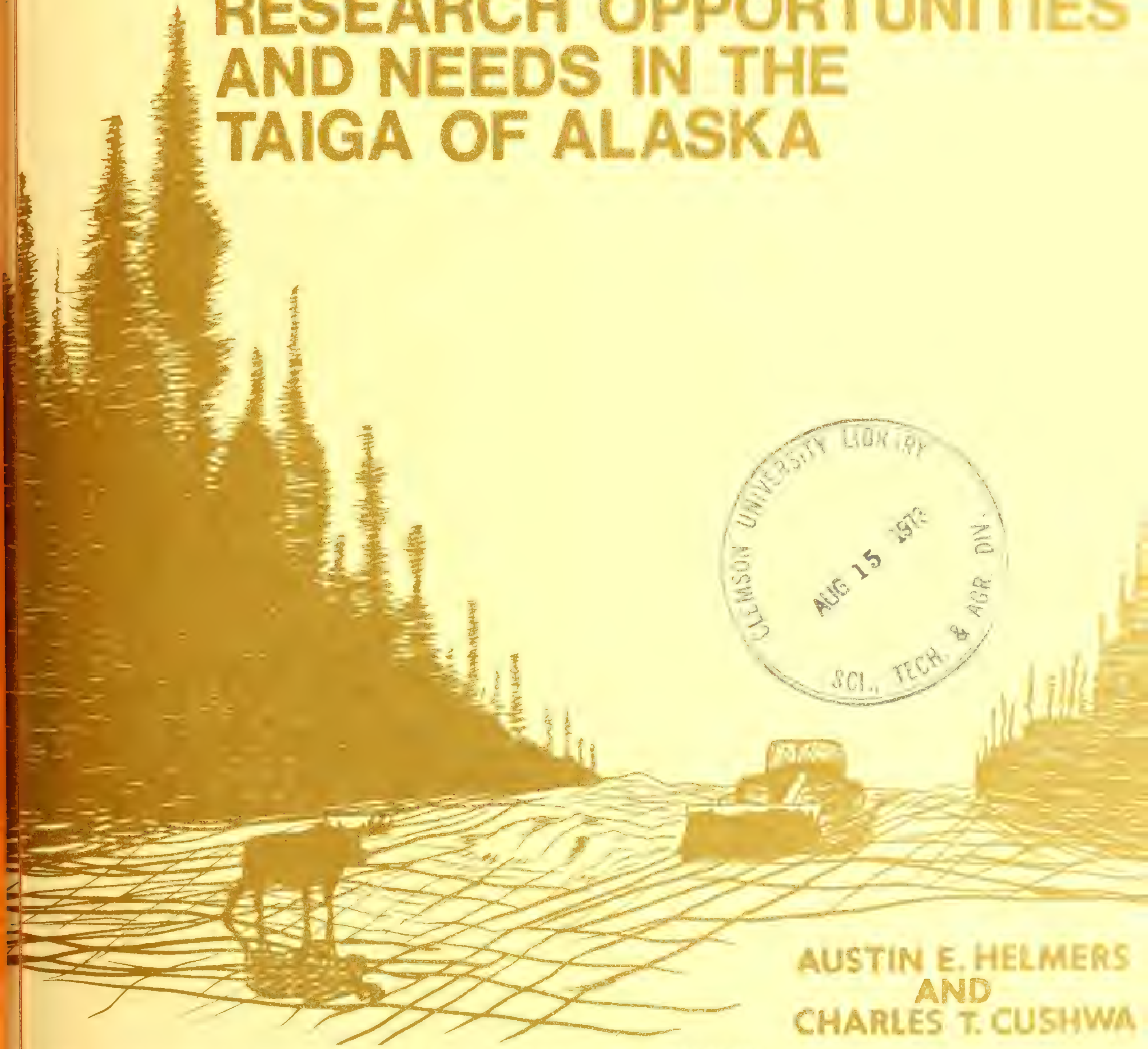
The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research will be made available promptly. Project headquarters are at:

Fairbanks, Alaska
Juneau, Alaska
Bend, Oregon
Corvallis, Oregon
La Grande, Oregon
Portland, Oregon
Olympia, Washington
Seattle, Washington
Wenatchee, Washington

The FOREST SERVICE of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW-2

RESEARCH OPPORTUNITIES AND NEEDS IN THE TAIGA OF ALASKA



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ABSTRACT

An appraisal of taiga (the northern forests of interior Alaska) environment research opportunities and needs was made based upon accomplishments since Alaskan statehood, current involvement of citizens in resource issues, information needs incident to the National Environmental Policy Act of 1969, and needs of new resource managing agencies and changing ownerships brought about by statehood and the settlement of aboriginal land claims. Based upon this appraisal, it is proposed that the research needs can best be met through a multidisciplinary interagency program. The program suggests closer coordination among several departments of the University of Alaska and a number of State and Federal agencies currently involved in applicable research. The urgency of research implementation is related to rapid change and diminishing opportunity to insure orderly development of Alaska's resources.

Taiga environment information needs encompass five major problem areas:

Ecology--the fundamental climate-soil-water-air-flora-fauna relationships in natural and perturbed environmental systems.
Fire effects--characteristics of fire, fire ecology, and the effects of fire upon entire resource systems.
Water--precipitation-soil-plant-runoff relationships are complicated by permafrost. Soil erosion and water quality will respond to fire, fire control methods, land clearing, insect outbreaks, road construction, and industrial developments.
Culture--people will determine resource management; thus, what "Alaska" means to people the world over will influence the extent to which resource development and use is consistent with preserving environmental quality and natural beauty.
Economics--goals and objectives in resource developments, and development of plans and policies.

Keywords: Taiga, Alaska, research, resource management, environment.

INTRODUCTION

The purpose of this discussion is to focus attention on research opportunities and needs in the taiga of Alaska and suggest a means of getting on with the tremendous task of obtaining facts upon which to evaluate future resource management alternatives.

The Alaskan taiga has acquired international significance as people look to the Arctic and subarctic to meet resource needs of an expanding population and economy. In addition to food, fuel, and building material, there is an increasing need for a healthful environment, recreational opportunities, and esthetically pleasing landscapes.

Taiga is a circumpolar zone of predominantly coniferous forest, with tall trees in dense stands along the southern edge which become progressively shorter and less dense toward the northern tree line. The Alaskan taiga, located primarily in the interior of the State, is bounded on three sides by the south slopes of the Brooks Range, the north and northwest slopes of the Coast Mountains, and the Canadian border. The western boundary includes the lower Yukon and Kuskokwim River valleys, Norton Sound, base of the Seward Peninsula, and the lower Kobuk and Noatak River valleys (fig. 1). Approximately 56 percent of the 152 million hectares (375 million acres) in the State is in the general zone of taiga. About half of the Alaska taiga zone consists of forests and bogs (fig. 2), the other half of alpine tundra, bare rock, permanent ice, and snow.

Knowledge about the Alaskan taiga began accumulating to a small extent as the Russians occupied "Russian-America" and increased when the United States explored the new land it bought from Russia in 1867. By the 1920's, research on various renewable resources received attention with the growing awareness of their potential usefulness and of the need for management. A big impetus in research, concerned mostly with engineering problems, came in the 1940's with expanded military activity.

A steady growth of research related to natural resources in the past two decades has contributed to an understanding of the complexities of taiga environments, how exceedingly sensitive they are to change, and to a realization of how much research is needed. Nevertheless, only limited funds have been expended on research to determine the impact of man's activities on the Alaskan environment.

In contemporary Alaska, man is only beginning to influence the operation of natural systems on a substantial scale. As human activities increase, the need for information about resource management and about social and economic factors also increases. Problems that will confront all resource managers in Alaska are beginning to be recognized. There are many opportunities for studying natural ecological systems and for developing basic information about them which will be necessary for decisions in a broad spectrum of resource problems.

The National Environmental Policy Act of 1969 requires Federal agencies to understand and to explain to the public the impact of agency activities on the environment. A lack of understanding of the basic ecological processes in the taiga is affecting development and use of Alaska's resources. The delay in approval to construct the 1,290-kilometer (800-mile) pipeline across Alaska is an example of how this void in basic information affects use of Alaska's resources.

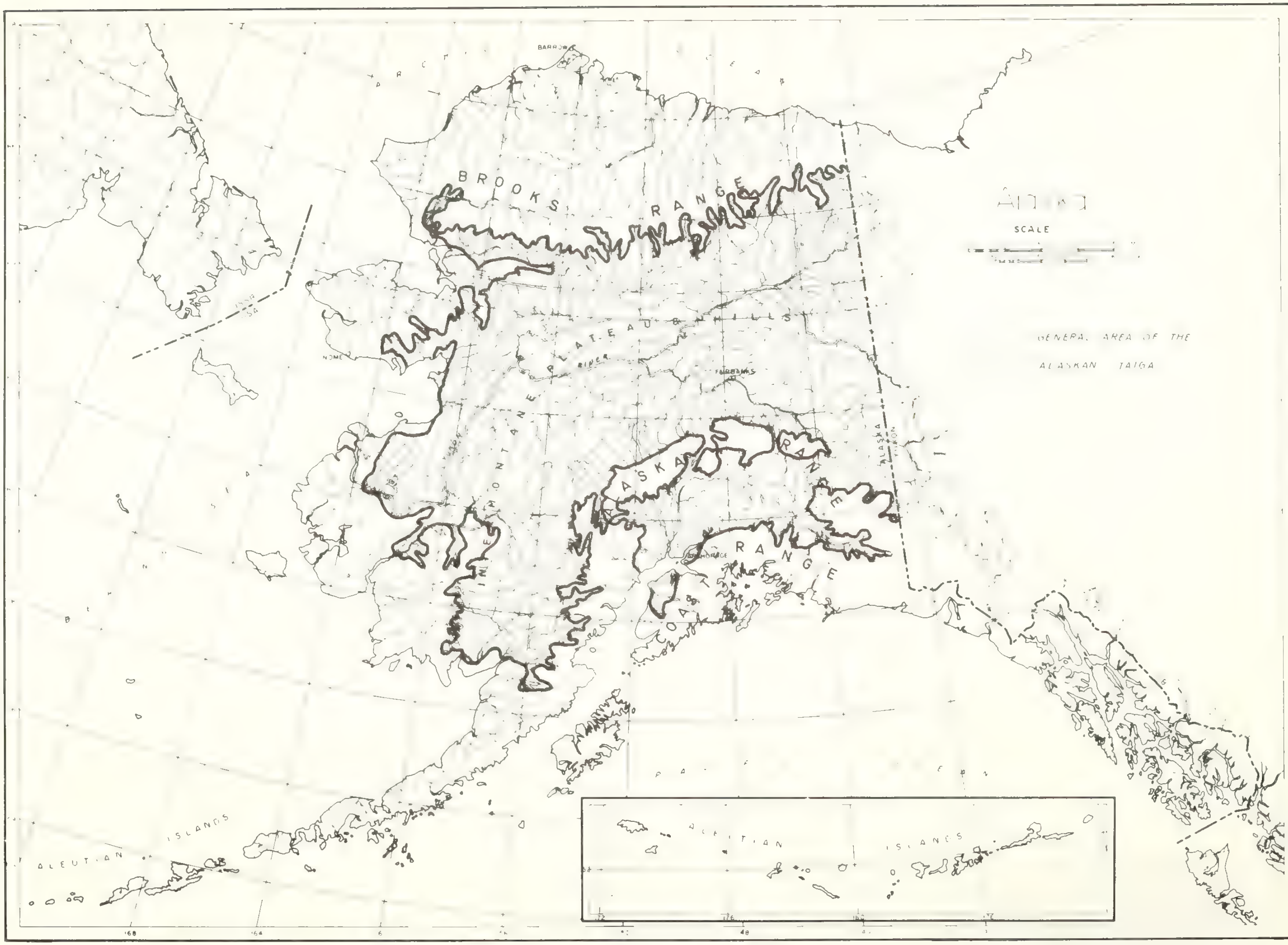

Figure 1.--Map of Alaska showing major mountain ranges and general zone of taiga.

igure 2.--Alaskan taiga, showing a variety of vegetation types, ponds, and bogs, and a wildfire. Swanson River, 1969.

A new appraisal of research needs and opportunities and a reevaluation of existing research programs are timely.

There has been more than a decade of research accomplishment in interior Alaska since statehood. This was a formative period in which socioeconomic progress and resource use gradually acquired more purposeful direction. Policies about environmental quality became clearer and firmer. The average citizen became more deeply involved in resource issues.

These factors, combined with settlement of the aboriginal land claims and State and Federal land selection, have created new resource managing organizations, changing ownerships, and changing management aims which have immediate needs for guidelines.

SETTING

Interior Alaska landscapes are a product of:

1. Recent geomorphological history which includes glaciation in the three major mountain ranges, associated processes in the intermontane valleys, and sensitively balanced ecosystems in early stages of development.

2. Mean annual temperatures ranging from -10° C. (13° to 15° F.) in the Brooks Range to about 2° C. (35° F.) on the base of the Aleutian Chain. Annual precipitation ranges from 178 to 760 millimeters (7 to 30 inches) over these same zones; frost-free days range from 50 to 130 annually. Daylight varies from 20 to 24 hours in June to 0 to 4 hours in December.

3. Continuous or discontinuous permafrost (permanently frozen ground) underlying most of the area. This factor is characteristic of the interior of Alaska and many other lands at high latitudes.

4. Lightning-caused wildfires. These have occurred in the interior since prehistoric times--the taiga is a fire environment with its flora and fauna adapted to, or dependent on, frequent disturbance by fire.

5. Frontier environment. The vast "unspoiled" open space is the popular conception of Alaska.

RENEWABLE RESOURCES

Interior Alaska includes wood, water, wildlife, recreational, and cultural resources.

WOOD

The 43 million hectares (106 million acres) of taiga classed as forest land in the interior constitute about 15 percent of the tree-covered land in the United States. About 9.1 million hectares (22.5 million acres) of the taiga are classed as commercial forest land and support a net growing stock volume of 404 million cubic meters

(14-1/4 billion cubic feet)(Hutchison 1967). These forests are capable of a sustained harvest of 10 million cubic meters (358 million cubic feet) of wood annually. However, production and use of the wood resource are limited by the northern environment.

The relationships of environmental factors to tree or forest growth are not well understood. The mosaic of taiga vegetation is attributed to fire (Lutz 1956). In some instances fire has indirectly but significantly changed soil temperatures and vegetation. River-bottom white spruce sites may deteriorate due to lowering soil temperatures and rising permafrost levels as shade increases from the developing stand (Viereck 1970). Increased timber harvesting heightens problems of spruce regeneration, which is inadequate under current logging practices (Zasada 1972) and creates an undetermined impact on the environment.

WATER

The annual water crop from interior Alaska watersheds is estimated at 617 billion cubic meters (500 million acre-feet). This is about one-fourth of the United States freshwater runoff and of correspondingly great power potential. The rivers are of major importance in transportation, fish spawning, and recreation, domestic, and industrial uses.

The abundance of water does not preclude water problems. Major rivers carry heavy sediment loads, related to numerous tributaries that arise from glaciers and icefields, and to the natural meandering of these large watercourses in broad alluvial valleys. Watersheds without glaciers and permanent snow usually produce water of good quality and of major importance to fish and human use, but the soils of such watersheds are highly erodible. In the cold-dominated climate, some streams and rivers are believed to freeze to the bottom during the long winter, and in many cases overflows and groundwater seepages freeze into large deposits of "stream icings" ("aufeis"), which may persist well into summer.

Related to precipitation and temperature distribution, streamflow patterns vary greatly with high flows during the spring breakup, moderate but variable flows (with storm flows sometimes exceeding spring flows) during the summer, and low or no flows during the winter.

Water supply, despite its annual quantity, is a potentially serious problem and will require conservation and management in connection with man's uses. Floods occur and cause significant destruction along main streams. The Fairbanks flood of 1967 was the largest in recent times, causing damages in excess of $170 million.

WILDLIFE

The history of Alaska is closely tied to fur, fish, and game. Until Alaska was purchased by the United States, fur trading was the main industry. Commercial fishing, which began in 1868, then became the main industry and still ranks as one of the most important. Mining, especially in its early years, would not have been feasible without game and fish as sources of food.

Dependence on fish and game as a source of food, combined with the importance to the State's economy, plus the need to satisfy demands for sport hunting and fishing place consumptive uses of wildlife high on the list of valuable resources of the State. Nonconsumptive uses, such as nature study, photography,

and seeing birds, animals, and fishes in their natural habitats, are also important considerations.

Alaska must also consider her role in insuring the continued protection and enhancement of breeding habitats for many migrating species, as well as her international responsibility in preservation of endemic species in danger of extinction elsewhere. Consequently, management of Alaska's wildlife resources will continue to be one of the most complex issues facing resource managers.

RECREATION

Where but in Alaska can one walk from an icefield to the ocean in half a day, or drive for hours with a view of the highest mountain in North America, or visit primitive cultures and experience a step back in time where man is still living close to nature?

The importance of recreation does not mean that finding its place in the resource management balance will be simple. For example, Rogers (1962, p. 53) pointed out that "Alaska's vast empty spaces...have tangible or intangible values as 'amenity resources' in a society which is becoming increasingly congested, as recreation resources, and as elbow room for the perfection and maintenance of a modern military machine [referring to national defense withdrawals in Alaska]. Unfortunately, these uses are not entirely compatible and, as in the case of the more traditionally defined natural resources, choices must be made."

Outdoor recreation in Alaska is forecast to continue rapidly increasing, based upon doubling of the State's population and a sevenfold increase in the number of tourists during the next 30 years (State of Alaska 1970). The role of interior Alaska recreation will be important not only in relation to the needs of the United States and North America, but also to the needs of the rest of the world. The word "Alaska" has a special meaning to people the world over--a meaning that is usually related to wilderness, wildlife, and spectacular scenery in an uncongested environment.

CULTURE

Alaska's cultural dimensions vary from the metropolitan penthouse dweller to the wilderness trapper. Within this range the following groups are identified:

Resident

a. Indigenous or aboriginal peoples--Athapascan, Eskimo, and Aleut.

b. Nonindigenous peoples--from locations throughout the world.
   1. Permanent resident--Alaska is home.
   2. Temporary resident--people in Alaska for short periods of time, such as military personnel, some university students, or individuals with large companies who move frequently.

Nonresident

a. Visitor or tourist--in Alaska to see, use, or enjoy its resources but not to become resident.

b. Nonvisitor--hears about Alaska, sees it on television, or reads about it and is concerned, but does not come to Alaska to use its resources.

The 302,760 residents[1/] are scattered across the 152 million hectares (375 million acres) of Alaska in a variety of settings--ranging from native villages, towns, and metropolitan areas to the individual homestead or wilderness cabin. These resident groups have a wide array of ideas, experiences, education, philosophies, values, and concerns about resource use and environmental quality.

Complexity of the cultural environment is increased when the nonresident dimension is added. Opinions, concerns, and ideas are frequently based on a brief visit, reading, or television.

Individuals from all these groups influence the future of Alaska's environment and resources.

DIMENSIONS OF RESEARCH NEEDS

The urgency and scope of research needs are determined by the rapid change and the diminishing opportunity to insure orderly development of Alaska's resources. Alaska, the largest of the 50 States, contains more land than the combined States of Washington, Oregon, California, Arizona, and Nevada.

Current and impending economic and social developments, such as expanding recreation and tourism, improving transportation systems, oil, gas, coal, and mineral exploration and development, and settling aboriginal land claims, are requiring long-term resource use and management decisions. Yet the capability of this northern environment to support man's interests and activities has not been determined. A statement made in 1966 holds true today: "What the state needs now more than anything else is more precise and integrated knowledge about the northern environment and related problems of land management and development" (Cooley 1966, p. 93). Development of the needed research capability to provide management alternatives is in its infancy.

The depth and complexity of research needs are determined by the characteristics of taiga. The taiga is one of the youngest, more primitive and least understood biomes or plant-animal systems on earth. The cold-dominated environment, manifest in part by large areas underlain by permafrost, affects life processes and biological production. Although temperature is a dominant factor, other parameters, such as solar radiation, moisture, nutrients, and the geologic youth of the land surface, are also important influences on flora and fauna. The combination of severe environment and the paleoclimate has led to ecosystems in which an individual element of the system is extremely sensitive to, or dependent on, the other elements. As a result, populations or environmental parameters fluctuate dramatically following small disturbances; the passage of a tracked vehicle leaves a scar for decades; postfire recovery of lichen forage in the alpine tundra takes 40 to 100 years; and the disturbance of a gentle slope underlain by permafrost can cause large-scale soil movements and stream sedimentation within a single season.

The complexity of taiga management is due in large measure to the cause and effect relationships between permafrost and terrain, climate, flora, and fauna. It is the close interrelationship and delicate balance of factors that is meant by the frequently mentioned "fragile ecology," with reference to interior Alaska.

1/ *1970 census.*

There is an increasing demand for coexistence between industrial progress and natural beauty. Hence, in the taiga of Alaska, resource use for economic gain must include maintenance of environmental quality. However, the basic cost of doing business in interior Alaska will continue to be high. Technological advances make possible continuation of many basic operations year-round but not without increased cost.

The more critical gaps in knowledge about five major problem areas involve the following informational needs.

ECOLOGY

Research in this area deals with fundamental climate-soil-water-plant-animal relationships in natural and disturbed systems. Information is needed to:

a. Determine the environmental conditions and plant successional trends leading to major vegetation types, such as white spruce, paper birch, and aspen, and the vegetation composition and successional responses to such disturbances as fire, clearing, logging road construction, and recreational use.

b. Develop a habitat classification system based upon air-soil-water-plant-animal relationships and interactions in disturbed and stable systems.

c. Determine growth patterns for white spruce, aspen, paper birch, black spruce, and balsam poplar and correlate these patterns with environmental patterns, especially temperature, soil moisture, and soil nutrients.

d. Determine the effects of abiotic factors on the dynamics of forest and range insect populations.

e. Determine the productivity of taiga ecosystems for wildlife food and the degree of use by different wildlife species; develop procedures for classifying habitat production in terms of wildlife.

f. Identify successional stages of vegetation that are critical in habitat requirements for different wildlife species and determine the effects of disturbance on wildlife habitats.

g. Develop simulation models to predict the consequences of management manipulations on productivity and biomass, energy flow, and decomposition and nutrient turnover in cold-dominated ecosystems.

FIRE EFFECTS

The particular susceptibility of the taiga to fire is due to climate and vegetation types. Fundamental factors in fire ecology are fire intensity and behavior, which are functions of fuel, weather, and topography. Information is needed on:

a. Fire characteristics and the ecological effects of fire on interior vegetation systems. Present knowledge is only general.

b. The effect of fire on hydrologic factors and soil stability, known now only in principle.

c. The effects of fire upon entire resource systems.

Filling this informational gap will require a continuing integration of knowledge about how fire affects taiga resources, both social and ecological.

WATER

Watershed dynamics is one of the least understood aspects of the taiga. The precipitation-soil-plant-runoff relationships appear to be extremely complex, probably due in a large measure to permafrost. Information is needed to:

a. Develop mathematical or conceptual models of hydrologic processes.

b. Develop methods and obtain accurate hydrologic data on several

undisturbed localities preparatory to designing research in disturbed areas.

c. Quantify soil erosion and changes in water quality accelerated by fire, fire control methods, land clearing, large-scale insect defoliation, road construction, and industrial developments such as the trans-Alaska pipeline.

CULTURE

As land selection proceeds in Alaska, four major groups of landowners will emerge:

State of Alaska
Alaska native
Individual or corporate
Federal Government.

Several State agencies have a long history of resource management in Alaska through experience gained in the territorial government some years before statehood. Since statehood, the State agencies have been assuming increasing responsibility as the State's landholdings grow. Concerns of the Department of Natural Resources parallel those of the Federal Government, with the added burden of making larger inputs into the State's new economy. Therefore, an immediate concern is how to use resources under the jurisdiction of the State for economic gains in keeping with local, State, national, and international concern about environmental quality.

The Alaska native is the most recent group concerned with resource management. The granting of 16 million hectares (40 million acres) of land to sustain an increasing quality of life for the native will probably place more intensive demands on this land than will be placed on the land under the jurisdiction of the State.

The individual landowner in Alaska is confronted with similar needs, i.e., to make a living from the land under his ownership. Consequently, his demands and impacts will parallel or become more intensive than those of other groups.

The Federal Government currently manages public resources according to a variety of policies, of which the National Environmental Policy Act of 1969 is one of the more recent. These policies attempt to maintain or enhance environmental quality while developing and using resources. Federal resource management agencies have accumulated considerable experience in Alaska as well as in other States. The Federal Government is therefore able to put proven policies and methods into use and to assist new management groups in developing initial guidelines.

What has this to do with cultural or social problems? Policies and philosophies about resource use and environmental quality arise from people. We know that in Alaska there are tremendous variations in experience, attitudes, values, and philosophies among cultural groups. Therefore, a reasonable deduction seems to be that a wide range of attitudes and policies concerning use of Alaska's resources may emerge from these diverse groups.

Ideas of the indigenous people may vary considerably from those of the nonindigenous group. Within the nonindigenous group the permanent residents' ideas may not be compatible with those of temporary residents. No doubt the resident and the nonresident will view the use and development of Alaska's resources differently. Each cultural group will have ideas, opinions, and philosophies that will influence policy and ultimately the use and development of Alaska's resources.

Therefore, the desires of the people must be considered if recurring issues such as the proposed Rampart power project, the trans-Alaska pipeline, and nuclear device testing on Amchitka Island are to be resolved. Information is needed to determine:

a. What is the "real value" of Alaska? What does the word "Alaska" mean to people the world over?

b. What is the State government's responsibility to its citizens, the citizens of the other States, and the rest of the world?

c. How do these meanings relate to development of the State's resources?

d. What changes in the meaning of "Alaska" have taken place during the past few decades as transportation, communication, and industrialization increased?

e. What changes should we expect during the next decades?

f. What action should be taken to insure orderly development and use of resources consistent with preservation of environmental quality and natural beauty?

Answers must come from Alaskans as well as from residents of the other 49 States who share the responsibilities, costs, and benefits of a democratic society, and from interested people in other countries. Only if this information is coupled with the basic biological facts on land capability and condition in this northern environment will we be able to provide a sound basis to resolve conflicts of interest in the future development and management of the State's resources.

ECONOMICS

The complex economic situation in Alaska has been and is being studied by experts on the national, State, and local levels. According to Johnson and Jorgenson's review (1963, p. 22):

> The high cost of living is attributable principally to the cost of import of most of the necessities of life, to the naturally greater expense of living in a far-north environment, and the business philosophy that is keyed to high interest and a quick return on investment.
>
> In the process [of high prices and high wages interacting to keep the cost of living going up] the competitiveness of Alaska's resources and products on outside markets seriously suffers.

Nathan (1970), in summarizing the economy of Alaska from a national view, felt there were many problems of an economic nature to be solved, and challenges for the future were the combination of a vigorous rate of economic growth, a wholesome and healthy environment, and the degree to which Alaska has or develops her human resources. He believed that:

a. The citizens of Alaska and their leaders should seek to determine their goals and objectives, taking into consideration the needs and wants of the people of Alaska relative to the expanded resources that will be available to them, and

b. Alaska needs to undertake some imaginative planning and must formulate carefully conceived policies to avoid much waste and missed opportunities.

OPPORTUNITIES FOR MULTIDISCIPLINARY RESEARCH

Management activity influences the taiga system; therefore, research capability must also be aimed at determining the impact of man's decisions and activities on the system rather than his impact on a single element or part.

Since most elements of these systems are extremely sensitive to or dependent on other elements, few studies can

be unique to single disciplines. Komarek (1971) summarized such multidisciplinary needs in terms of a proposed cooperative ecological experiment station for Alaska. This approach had been discussed in Alaska previously and has been implemented elsewhere; the Taiga Research Station of the University of Alberta, the Subarctic Research Station of McGill University, and the Finnish Kevo and Oulanka Stations are examples.

Research on any one facet of the taiga system necessarily involves many interacting factors of the environment. The informational gaps identified previously are not mutually exclusive with respect to environmental factors, research studies, or research disciplines. For these reasons, a multidisciplinary research approach, including social, economic, and ecological aspects, should be considered for the taiga in Alaska.

Also, there are probably few large areas where the opportunities for interagency, public and private, cooperation and coordination in research are greater than in interior Alaska--and there are probably few areas where interests in such cooperation and coordination provide a better climate for it. Cooperation and coordination with agencies, groups, and individuals must be a significant feature of this approach to fill major informational gaps as quickly as possible. Working arrangements among agencies need to be coordinated and cooperative agreements established or strengthened. Examples are the University of Alaska and several universities in the conterminous States; the State of Alaska Departments of Natural Resources, Fish and Game, and Environmental Conservation; National Weather Service; U. S. Geological Survey; U. S. Army Corps of Engineers Alaska District and the Cold Regions Research and Engineering Laboratory; Soil Conservation Service; Institute of Northern Forestry of the U. S. Forest Service; Bureau of Sport Fisheries and Wildlife; Bureau of Land Management; Environmental Protection Agency; Alaska Agricultural Experiment Station; and the International Biological Program in the coniferous and tundra biomes.

A steady growth in research since the mid-1940's by the University of Alaska and a number of other universities and agencies, mainly through contracts, grants, and the internal programs of some agencies, was recently supplemented with what might be termed "ad hoc" research related to environmental issues associated with the proposed 1,300 kilometer trans-Alaska pipeline. Some of this research is funded or conducted by oil companies, some is conducted by resource management agencies, and some is being done under the International Biological Program's Tundra Biome research.

By Executive decision, the Department of Agriculture is responsible for Federal forest research, which is in turn delegated to the Forest Service by departmental administrative regulations.

Forest Service research, as a continuing activity in interior Alaska, began in 1957. During 1970, the U.S. Forest Service recognized the opportunity for a more active role in developing intensive taiga research programs. Consequently, a multidisciplinary research unit was established in July 1971 with seven scientists to develop the new research program at the Institute of Northern Forestry. The mission of this group is to understand the ecology of the taiga and associated environments and to provide a sound basis for orderly development of resources consistent with maintenance of environmental quality.

The President, in his February 8, 1971, message on environment to the Congress, stressed the need for Federal cooperation with the State of Alaska in a land use planning effort for the area north of the Porcupine, Yukon, and Kuskokwim Rivers. This cooperative agreement was accomplished November 22, 1971. The Northern Alaska Planning Study Team, consisting of more than 20 Federal and State employees, was assembled with the objective to collect, analyze, and display data in developing a regional land use policy for northern Alaska within 2 years. This effort was expanded in August 1972 into the Resource Planning Team, Alaska Land Use Planning Commission.

All of the present and anticipated efforts by these groups bears directly on the taiga environmental research opportunities. Therefore, it is essential that this program coordinate and participate in common fields of interest.

SHORT-TERM PROGRAM

It is highly urgent that a multidisciplinary research program for the Alaska taiga be implemented. Alaska provides a rare opportunity for us to combine all information, experience, and technology with the desire to protect our environment and demonstrate that we can use and develop Alaska's resources without destroying her natural beauty and environmental quality. Modern man can live in harmony with nature--we should not pass up this excellent opportunity to demonstrate our capability. By this view, the overall research need is to understand the environments and the consequences of technology upon them.

GEOGRAPHIC LIMITS

Limitations in physical facilities and manpower preclude research on all problems of the whole of interior Alaska. The immediate program should be limited on geographical rather than agency, disciplinary, or ecological lines. That is, within a key area the major ecosystems should be considered. The key area should be the middle and lower Tanana River valley and the adjacent Tanana-Yukon uplands. This area is selected because it is representative of the Intermontane Plateau, the landform of largest extent in the interior, and the area of rapidly expanding industrial development and resource use, with related problems of environmental protection. This would not preclude attention to other areas as opportunities and the need to formulate future program plans arise. The main program effort would be centered around Fairbanks.

Due to the limited accessibility of potential study sites, research should be concentrated on a few study areas to the extent consistent with study objectives, with major research efforts concentrated on the Caribou-Poker Creeks Research Watershed and the Bonanza Creek Experimental Forest. Supplemental study areas will be needed, however; and consideration should be given to establishing areas representing the wide range of ecological conditions in the taiga of Alaska. These areas would be used to test the impact of man's activities on the environment, while appropriate portions of each area would be maintained as research natural areas to preserve and study natural processes in taiga systems.

PROGRAM LIMITS

For some time, analyses of research needs and the subsequent selection of individual studies should be flexible in approach, scope, and detail in response to new information, to changing needs of

resource-oriented programs, to gradually intensifying management practices, and to the climate for financial support. Based on a reasonably clear view for the next few years, a 5-year research program time unit is logical.

The need for information about the Alaskan taiga over the next 5 years will be possibly greater than for any previous or future 5-year period in Alaska's history. It is this period that will encompass the major thrust of the Northern Alaska Planning Study Team efforts. It is within this period that the resource management plans, and perhaps management precedents, will be initiated on as much as 16 million hectares (40 million acres) of land involved in the aboriginal claims settlement and on up to some 40 million hectares (100 million acres) selected by the State under the provisions of the Statehood Act.

A minimum 5-year staffing level by disciplines including scientists from all agencies would result in the following level of research effort:

	Man-years of effort needed annually
Ecology	4
Fire (control and effects)	8
Forest diseases	3
Forest insects	3
Watershed and aquatic habitats	3
Wildlife habitats	3
Social, economic, and recreation	3
Total	27

The cost to implement the proposed program is estimated at $80,000 to $100,000 per scientist man-year. A substantial contribution can be and is being made by university-State-Federal research groups; however, these efforts could be more closely coordinated through increased funding using existing research facilities to develop an integrated program of research to solve the previously mentioned problems.

ANTICIPATED ACCOMPLISHMENTS

The foregoing research program is to provide information for major developments including: some 40 million or more hectares of land coming under new management and ownership--the State for the remainder of Statehood Act land selection, and the Eskimo and Indian village councils for the land allotments in the settlement of their claims; intensifying management of Federal lands as manifested in the activation of the Northern Alaska Planning Study Team; expanding needs of agencies responsible for monitoring or controlling environmental quality; and the demands for determining the environmental impacts of public management of resources.

The anticipated accomplishments, to be attained to a level effective for resource management, are:

a. Determination of fundamental ecological relationships in resource management in order to provide for resource use and benefits with the least environmental damage and to predict the results of different management systems.

b. Effective fire control methods developed from research on weather modification, lightning sensing, fire danger rating, fire detection and reconnaissance, fire control planning, and fire attack methods.

c. Determination of the relationship of wildlife to the economy of interior Alaska, and the impact of fire, industrial, and recreational developments on wildlife use and management.

d. Determination of insect impacts on vegetation important for wildlife forage and for recreation enjoyment, and development of control methods for minimizing impacts and maintaining environmental quality.

e. Interim guidelines for resource managers--State, Federal, and private--based on available information from all outside and local sources with the understanding that modification and revision will be necessary as research results and experience are gained under Alaskan conditions.

f. Determination of the "value" of Alaska to Alaskans as well as to other people of the United States. As methodologies develop, consideration should also be given to expanding this survey to the world population.

g. An evaluation of the basic capability for fulfilling recreational needs on a sustained basis while maintaining maximum environmental quality.

h. A determination of the productive capability of the land and environment, as basic to assessing the economic needs, present and future, of the State. The supply of raw materials, feasibility of using these resources, and the real need or demand for products purchased are basic informational gaps.

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Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Development and evaluation of alternative methods and levels of resource management.
3. Achievement of optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research will be made available promptly. Project headquarters are at:

Fairbanks, Alaska	Portland, Oregon
Juneau, Alaska	Olympia, Washington
Bend, Oregon	Seattle, Washington
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1973
USDA Forest Service General Technical Report PNW-3

AERIAL SPRAY ADJUVANTS for Herbicidal Drift Control

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ABSTRACT

Increased public concern about pesticides requires that foresters reduce drift and insure precise application of herbicides to the areas requiring treatment. Drift control is necessary near waterways and other ecologically sensitive areas. This publication discusses available drift control adjuvants for herbicidal sprays. These include invert emulsions, thickening agents, particulating agents, and foam sprays. Commercially available adjuvants are described and their use, advantages, and disadvantages are discussed. Thickening agents and foam sprays show special promise for drift reduction in aerial application of herbicides on forest lands.

KEYWORDS: Silviculture, brush control, herbicides, aerial sprays.

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly. Spills of herbicides or spray adjuvants should immediately be cleaned from work surfaces and mixing platforms. Spray adjuvants such as Vistik, Dacagin, Norbak, and foaming agents are especially slippery and should be immediately flushed off with water.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

PROTECT

Use Pesticides Safely

FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

CONTENTS

GLOSSARY

acid equivalent	The amount of parent acid that has been chemically converted into esters, amines, or other salts.
additive	A substance added to a herbicidal formulation or spray mixture to increase effectiveness of the active ingredient: i.e., emulsifiers, solvents or co-solvents, wetting agents, buffering agents, penetrants, etc.
adjuvant	Synonymous with additive.
gel	A jellylike, coagulated colloidal dispersion of fine particles in a liquid; in this case, Dacagin in water.
micron	A unit of length equal to 1/1000th of 1 millimeter.
polymer	Compounds consisting of the same elements in the same proportion by weight, but differing in molecular weight.
p.s.i.	Pounds per square inch.
surfactant	A material added to a herbicidal formulation to aid and improve emulsification, dispersion, spreading, wetting, and other surface-modifying properties.
viscosity	Resistance of a liquid to change in form or flow due to internal forces and friction within the liquid.

INTRODUCTION

During the past 20 years, herbicidal sprays have become an indispensable tool in silviculture of Pacific Northwest conifers. Chemicals are widely used to release young conifers from competition of tree, shrub, and herbaceous species, to control vegetation along roads and utility rights-of-way, and to prepare sites for reforestation. In all applications, herbicides have proved a valuable time-, labor-, and money-saving tool for foresters.

Although foresters have compiled an impressive record in safe use of herbicides during this period, increased concern about the effect of pesticides on our environment requires that we become even more selective in our choice of herbicides and more precise in restricting application of chemicals to the desired area. If a site requires treatment, we must make every effort to prevent drift onto adjacent areas.

Drift and volatility are sometimes confused, for both may cause damage to untreated vegetation on adjacent areas. **VOLATILITY** refers to the ability of a herbicide to vaporize and change from a liquid to a gas in air. In contrast, **DRIFT** refers to the actual airborne movement of pesticides from the site of application to adjacent areas. This movement may be in the form of vapors, droplets, mists, aerosols, dusts, or other fine spray particles. Drift may occur with any herbicidal formulation--acid, ester, salt, or dust; but volatility is usually a problem only when using esters.

Many techniques and restrictions are already used by foresters to control drift and other spray losses. Volatilization is minimized by use of low volatile esters and spraying only when air temperature is below 75° F. and relative humidity above 50 percent. To minimize drift, aerial spraying is stopped when windspeeds exceed 6 miles per hour and when weather conditions are not suitable. Flying speed is limited to a maximum of 40 to 50 miles per hour and flying height is generally 30 to 45 feet above the vegetation. With conventional spray booms, drift is also controlled by use of a nozzle and orifice size that will produce the largest droplet compatible with coverage and desired effect upon vegetation. Larger and heavier droplets fall more directly, strike the vegetation more quickly, and drift less than small droplets or mists (fig. 1).

In the future, this will not be enough. For the past 2 years, the U.S. Forest Service has required use of particulating agents, spray thickeners, invert emulsions, or special spray equipment when applying aerial sprays near ecologically sensitive areas. In the future, *all* foresters will probably be forced to use such materials when applying herbicides near sensitive areas. This report was prepared to acquaint foresters with available drift reduction adjuvants, their use and limitations, and experience with such materials in field trials.

Figure 1.—Fine droplets may be lifted high above the helicopter in large whorls from the end of conventional booms. These fine droplets can drift with the wind or evaporate and drift in vapor form.

MATERIALS AVAILABLE

Chemicals now available to reduce drift of aerial sprays may be classified as: (1) invert emulsions, (2) spray thickeners, (3) particulating agents, or (4) foaming agents. All are designed to reduce drift by increasing droplet size by increasing viscosity of the spray solution or by producing a larger particle or globule that contains the herbicide.

Invert Emulsions

Invert emulsions are thick, white, water-in-oil emulsions that have a creamy or mayonnaiselike consistency. These emulsions, produced by special herbicidal formulations, are widely used to reduce drift in aerial application of herbicides on utility rights-of-way. They are also effective and useful in reducing drift during aerial application of herbicides on forest land.

In invert emulsions, small water droplets are dispersed within a continuous oil phase. In contrast, the more commonly used oil-in-water emulsions have oil droplets dispersed throughout the water phase (fig. 2). Many commercial formulations that produce invert emulsions are available. Most contain phenoxyacetic herbicides in the form of low volatile

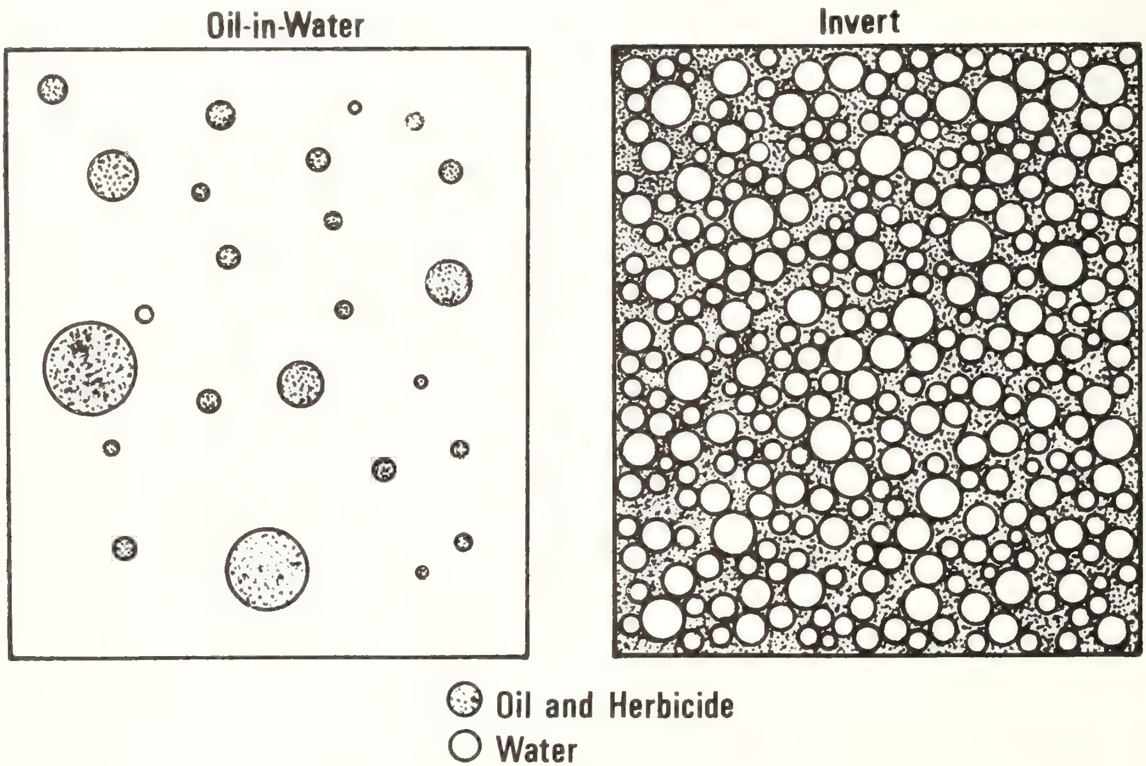

Figure 2.—Illustration of normal oil-in-water and invert emulsions with esters of 2,4-D or 2,4,5-T.

esters, oil soluble amines, or solubilized acids. In addition, Stull Chemical Company produces a series of inverting agents (trade name "Bivert") that produce invert emulsions when added to normal ester or water-soluble amine formulations of phenoxy herbicides. Similar Bivert agents are available for other herbicides.

Invert emulsions reduce spray drift by increasing the number of large droplets (fig. 3). Spray drift is not entirely eliminated, however, for some small droplets are produced during aerial application of any spray formulation. As with conventional sprays, the percentage of small droplets produced with invert emulsions is affected by such factors as nozzle tip design, orifice size, and nozzle orientation on the spray boom, all of which affect the degree of spray atomization. Emulsion thickness will also affect drift control. Thin emulsions produce more small, drift-susceptible droplets during aerial application.

Figure 3.—Spray droplets on thimbleberry leaves after aerial application of an invert emulsion of phenoxy herbicides at 10 gallons of spray per acre.

Viscosity of invert emulsions depends upon the ratio of oil to water and upon the size of the water droplets produced by agitation. Some invert formulations become thicker as they are agitated and pumped, for agitation increases the number of small water droplets. In the field, viscosity may be adjusted by varying the ratio of oil to water. As more oil is added, an invert emulsion becomes thinner and more fluid. Very thin invert emulsions can be applied through conventional aerial spray systems.

In invert emulsions of phenoxyacetic esters, the herbicide is contained in the layer of oil that surrounds each water droplet. Since oil vaporizes much more slowly than water, evaporation of water from the droplets is reduced, droplets striking the plant are larger, and on impact the oil-herbicide layer is immediately in close contact with plant foliage.

However, invert emulsions of phenoxyacetic esters are usually less effective in killing woody plants than equal amounts of similar esters applied in normal oil-in-water emulsions or in oil carriers. In part, the reduced effectiveness of invert emulsions, as compared to normal sprays is probably due to less complete coverage. As Kirch (1967) stated, the larger the droplet, the less there are per gallon of spray. In applying 8 gallons of spray per acre with a droplet size of 200 microns, deposition would average 1,150 droplets per square inch. Increasing droplet size to 1,000 microns would decrease coverage to 9.2 droplets per square inch. Kirch concluded that application of invert emulsions, particulated sprays, or thickened sprays would require two to three times more volume than conventional sprays to obtain a coverage that would insure an equal kill of woody plants.

Mixing techniques and proportions of oil and water are extremely important in preparing invert emulsions. The required amount of commercial herbicidal formulation is added to a specified amount of diesel oil or No. 2 fuel oil and premixed in a clean, dry spray tank equipped with good mechanical agitation. Herbicide and oil are agitated until thoroughly mixed. Then, with continued vigorous agitation, water is added to produce the amount of spray needed. The spray mixture is then recycled through the spray pump system and back into the tank for approximately 20 minutes to develop the desired viscosity (thickness). Mixing instructions on the herbicide label should be followed very carefully. The most important point to remember, however, is that **WATER IS ALWAYS ADDED TO THE OIL AND HERBICIDE MIXTURE**. The oil-herbicide mix is NEVER added to water.

Oil must be used in cleaning equipment after applying invert emulsions. As with other formulations, the oil used in cleaning equipment will contain an appreciable amount of herbicide. It should be placed in the spray tanks of the aircraft and sprayed on the last area treated. Final cleaning is then accomplished with a water and detergent solution as usual. This also should be applied on the treated area.

Special aerial spray equipment is required to apply thick invert emulsions. Suitable equipment includes Amchem Products' Spra-Disk apparatus, the Stull bifluid spray system, and the Hercules Pump Invert spray system. Invert emulsions can also be applied with the R-511 spray system developed by The Dow Chemical Company.

Both the Hercules and Stull bifluid systems require different herbicidal formulations than those suitable for application with the Spra-Disk or R-511. The bifluid system depends upon instantaneous or "flash" formation of the invert emulsion in a special mixing and metering chamber immediately before the pump. In flight, the oil and water phases of the spray are carried in separate tanks and pumped through separate lines to the mixing chamber. Formation of the invert emulsion takes place just before the spray leaves the aircraft.

When conventional spray booms, Amchem's Spra-Disk, or Dow's R-511 are used, the invert emulsion is premixed in a separate spray tank and then pumped into tanks on the helicopter. Elwell (1959) found that early invert emulsions were not stable and that separation occurred after 8 hours, but more stable formulations are now available. If separation does occur, inverts are readily re-emulsified by agitation. Flash emulsified formulations can also be premixed in a nurse tank and applied with the Spra-Disk or R-511 but may not be as stable as normal invert formulations marketed by major chemical companies.

Spray Thickening Agents

Thickening agents are natural or synthetic polymers that are soluble in water. They increase the viscosity of the water phase of spray solutions, thus increasing the size of droplets during spray application. Many thickening agents also function as stickers, increasing spray adhesion to leaves and reducing bounce and runoff from stems and leaves during spraying. Vistik (Hercules Inc.) and Dacagin (Diamond Shamrock Chemical Co.) are two spray thickeners that have been used successfully in aerial spraying on the west coast.

Thickened spray solutions were initially developed to decrease spray drift

by converting water-based herbicidal solutions or emulsions into viscous formulations. Water thickeners used in the paint and adhesive industries were first screened during 1962 by the Hydro-Electric Power Commission of Ontario (Suggitt 1965). Among these were colloidal clays, alginates, acrylates, vinyl ethers, and substituted cellulose derivatives. Most effective was a high-viscosity, water-soluble, cellulose polymer, hydroxyethylcellulose (HEC). This material, now formulated as Vistik, satisfactorily stabilized an aerial spray mixture of TCA (trichloroacetic acid) and a phenoxy ester for 100 hours. Dacagin was developed later.

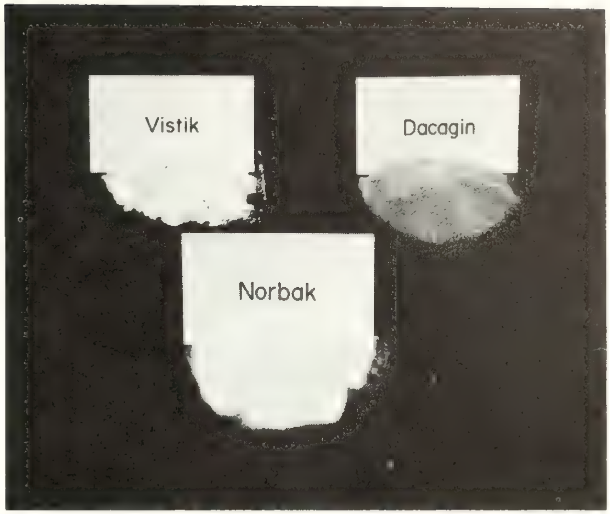

Figure 4.—Appearance of commercial forms of Vistik, Dacagin, and Norbak.

Although the primary function of thickened spray solutions is to decrease spray drift by increasing droplet size, increased viscosity is also claimed to slow evaporation of water from spray droplets and improve adhesion of spray to wet and dry foliage. Unfortunately, the higher viscosity may also reduce spread and coverage of the spray solution on leaf surfaces.

VISTIK

Vistik is a chemically inert, water-soluble hydroxyethylcellulose compound marketed as a fine white powder (fig. 4). When mixed with water, Vistik increases the viscosity of herbicidal sprays to improve drift control. It is readily soluble in water and in the water phase of oil-in-water emulsions. **It cannot be used to thicken oil carriers**. In the field, Vistik can increase viscosity of herbicidal sprays to an optimum for any specific ground or aerial application. The spray emerges in relatively large drops with a minimum number of fine droplets. The viscous droplets cling to leaves instead of running off, washing off, or blowing away.

The amount of Vistik required varies with the type of application equipment. In general, the amount used is not affected by the type of herbicide, for Vistik thickens only the water phase of herbicidal solutions. Four to 6 pounds of Vistik are usually added to each 100 gallons of spray solution.

For helicopter application at altitudes of 75 to 100 feet above the vegetation, Vistik-thickened sprays should have a viscosity requiring 75 to 80 seconds to drain a filled Vistik viscosity cup (fig. 5). This viscosity is obtained with about 4 to 6 pounds of Vistik per 100 gallons of spray mixture. When herbicides are sprayed from altitudes near 150 feet above vegetation, 6.5 pounds per 100 gallons of spray is suggested. Either D-8 or D-10 hollow cone tips without whirl plates on standard diaphragm tee-jet nozzles are recommended for optimum control with Vistik sprays. When spraying at low elevations of about 20 feet above vegetation, No. 8 flat fan

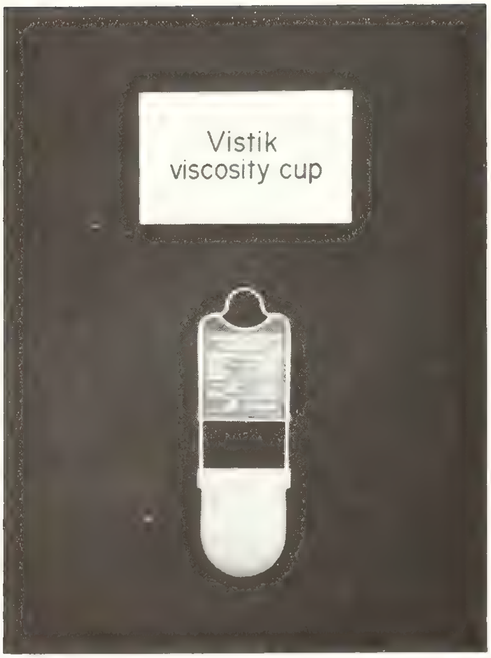

Figure 5.—Vistik cup for measuring viscosity of Vistik-thickened sprays.

nozzles have given good results (Fox 1967). Recommended pump pressures are 25 to 35 p.s.i.

With ground spray equipment, 4.5 pounds of Vistik are added per 100 gallons of spray mixture. No. 8 or 10 disk type spray tips are most satisfactory with hand guns operated at 75 to 100 p.s.i. With spray booms or fixed nozzles using fan tips, No. 60 or 80 tips with pump pressures of 50 p.s.i. are recommended.

In the field, Vistik solutions can be mixed in most herbicidal nurse tanks, but a tank with good mechanical agitation is especially recommended. Mixing instructions are specific and should be carefully followed. The recommended procedure is:

1. Fill the tank with the total volume of water desired for the spray mixture (DO NOT ADD THE HERBICIDE).
2. Turn on agitator.
3. Disperse the recommended amount of Vistik in the agitating water (fig. 6).
4. After 1 minute, add one-fourth pound of soda ash (sodium carbonate) per 100 gallons of water.
5. Continue agitation for 5 minutes or as long as necessary to set up the thickened Vistik-water solution.
6. Add the herbicide while continuously agitating the thickened mixture. When oil-in-water emulsions are to be used, first premix the desired amount of oil and herbicide, then add this oil-herbicide mixture to the thickened water in the tank.
7. Continue agitation until the herbicide is completely dispersed throughout the mixing tank.

After use of Vistik-thickened sprays, flush all tanks, lines, screens, and nozzles

Figure 6.—A funnel for adding and dispersing Vistik in the nurse tank by feeding the powder into a 2-inch bypass.

with water. Vistik solutions should not be allowed to dry in tanks or lines. When spraying is completed, thoroughly clean all spray equipment with water and detergent solutions, flush with water, and then spray all rinse solutions on one of the treated areas.

Water temperature has a pronounced effect on both mixing time and final viscosity of Vistik-thickened sprays. Vistik dissolves more slowly in cold water. Use of cold water in the spray tank will, therefore, increase mixing time (step 5) required to thicken Vistik-water solutions. In addition, cold water increases viscosity of Vistik solutions. Where water is taken from a cold mountain stream, the recommended rates of Vistik may produce solutions that are too thick. Warm water increases Vistik solubility, decreases mixing time, and reduces final viscosity of Vistik-water solutions.

Even in well planned spraying operations, batches of thickened spray must often be left temporarily in spray tanks because of adverse weather conditions, equipment breakdowns, or the end of a working period. If the spray solutions have cooled before spraying is resumed, viscosity may have increased and the spray solution may need to be thinned before application. In warm water or when nurse tanks have been left standing in the sun, solutions may be too thin. Therefore, it is always advisable to measure and correct the viscosity just before application. Viscosity can be increased by adding Vistik or decreased by adding water to the spray solution with continuous agitation. When water temperature is above 75° F., an increase of one-half pound of Vistik per 100 gallons of spray solution is recommended.

High viscosity Vistik spray mixtures for aerial application exhibit a marked decrease in viscosity within 24 to 48 hours as a result of enzymes present in water. The enzymes attack and degrade the cellulose thickener (Suggitt 1965). This decrease can be detected by a viscosity check before aerial operations are resumed.

When Vistik is used with certain water-soluble herbicide formulations that contain surfactants, bubbles may form during agitation and be stabilized in the viscous solution. Such bubbles can usually be eliminated by adding about 1 percent by volume of kerosene or diesel oil or small amounts (one-tenth percent by volume of total spray) of a defoamer such as Hercules Defoamer 357. The defoamer is very effective.

Water available in the field can vary considerably in hardness. Suggitt (1965) indicates that hard water has little effect on low-viscosity spray mixtures but may slightly increase thickness of high-viscosity aerial spray mixtures.

Suggitt also learned that mildly acid water (pH 5) retarded the rate at which hydroxyethylcellulose dissolved but gave satisfactory initial viscosities. However, viscosity decreased significantly with time, because of acid hydrolysis of the cellulose. With alkaline water (pH 8), thickening rate was reasonably rapid and viscosity of the mixture remained relatively stable. Sodium carbonate (added in step 4 of the mixing procedure) increases alkalinity of the water, speeds the solution rate of Vistik, and increases stability of the final mixture.

It seems possible that the increased pH of Vistik mixtures could reduce penetration and translocation of herbicidal esters. Kirch (1961) stated that maximum penetration and translocation of 2,4-D and 2,4,5-T apparently occur at pH levels

below 5 (Crafts 1953, Hamner et al. 1948). The presence of free acid in an emulsifiable form in an ester formulation increases acidity of the formulation. Although the pH of an ester containing no free acid would be approximately 7, one containing 5 to 10 percent free acid is in the range of pH 3 to pH 5. Penetration and translocation from an acid ester formulation are believed to be better than from a neutral ester without free acid in an emulsifiable form. Measured pH of four commercial formulations of low volatile esters of 2,4-D and 2,4,5-T were in the range of pH 3 to pH 4. Such formulations could conceivably lower the pH of water and oil-in-water carriers for aerial sprays in forestry, where spray volumes of only 5 to 10 gallons of spray containing 2 to 4 pounds acid equivalent of phenoxy herbicides are applied per acre. However, field measurement showed a pH of 8 in a 1,000-gallon batch of Vistik-thickened aerial spray on the Siuslaw National Forest. The spray mixture contained 3 pounds acid equivalent of low volatile esters of 2,4,5-T per 10 gallons of water.

In addition to reducing spray drift, Suggitt (1965) listed several other advantages of hydroxyethylcellulose as a spray thickener. He found it: (1) readily available, (2) required in only small amounts in each batch of spray, (3) light and easily transported, (4) easily handled and mixed in the field, and (5) formed viscosities of the wide range needed for both ground and aerial spraying. Vistik is compatible with almost all herbicides in water carriers or water-based sprays. Such sprays may be in the form of solutions, emulsions, or suspensions of wettable powders. It has been used successfully with amitrole-T, phenoxy esters and amines, picloram, silvex, diquat, and maleic hydrazide (Fox 1967).

DACAGIN

NOTE: *This adjuvant, manufactured by Diamond Shamrock Chemical Company, may not be available in the near future.*

Dacagin is described as a pseudo-plastic spray gel agent. It is a chemically inert polysaccharide-gum in granular form (fig. 4). It is composed primarily of naturally occurring carbohydrates, and a small amount of protein and organic acids, a trace of fats, and ash (Ekins et al. 1970). When mixed with water, Dacagin becomes a thin flowable gel that serves as a carrier for various herbicidal formulations including water soluble materials, emulsifiable concentrates, and wettable powders. Examples are water soluble amine salts, ester formulations of 2,4-D and 2,4,5-T, and atrazine. As with Vistik, **Dacagin cannot be used to thicken oil carriers**.

Dacagin gels are both pseudo-plastic and thixotropic. The practical aspect of pseudo-plasticity is that initial viscosity of the gel is dependent upon the rate of agitation when Dacagin is first mixed with water. The slower it is mixed, the greater the initial viscosity of the gel. Once attained, this increased viscosity is irreversible. The gels do not become more fluid on standing.

Because they are also thixotropic, however, Dacagin gels decrease in viscosity when agitated or pumped. They regain their initial viscosity after agitation or pumping is stopped. Practically, this means that Dacagin gels are low in viscosity while being agitated and pumped but regain their high viscosity after they leave the spray nozzle. As a result, Dacagin gels can be applied with conventional spray equipment.

The amount of Dacagin to be added per 100 gallons of spray solution depends on application equipment, formulation, and conditions of use. With ester formulations, 4-1/2 to 5-1/2 pounds of Dacagin are added per 100 gallons of spray solution. With water soluble amines, 5-1/2 to 6-1/2 pounds of Dacagin are added per 100 gallons of spray solution.

Mixing instructions are quite simple. The recommended procedure is:

1. Place the required amount of water in a clean mixing tank.
2. Start agitation of water. Agitation should be vigorous enough to maintain a uniform distribution of Dacagin throughout the water in the tank.
3. Slowly sprinkle in the required amount of Dacagin while continuing agitation.
4. Add herbicides.

A centrifugal or positive displacement pump should be used to pump Dacagin gels from the mixing tank to spray tanks. The pump should be equipped with 1-1/2- to 2-inch hose fittings on both intake and discharge ends of the pump.

Although Dacagin can be applied with conventional spray equipment, the modified R-511 spray system should be especially good for applying Dacagin gels. All screens in nozzles and spray lines must be 50-mesh or larger. Recommended pump pressures for application of Dacagin gels are 25 to 35 p.s.i., depending upon thickness of the gel.

It is important that enough Dacagin be added to attain the desired viscosity when Dacagin gels are first mixed. If the gel is too viscous, it can be thinned by adding more water with vigorous agitation. Thickening is much more difficult. If necessary, more Dacagin may be added by first slurrying the granules in water and then adding the slurry to the tank. This procedure, however, is difficult and not recommended.

Spray equipment should be kept clean. The gel should not be allowed to dry in spray tanks. When spraying operations cease, the spray tank and other equipment should be flushed with water to remove any gel that might dry to form a film and foul screens and nozzles. Before storage, more thorough cleaning is recommended. It is suggested that the spray equipment be cleaned with a detergent solution and then rinsed with clean water before storage.

LO-DRIFT

A new product is Lo-Drift manufactured by Amchem Products, Inc.

Lo-Drift is a water soluble polyvinyl polymer that increases viscosity of herbicidal sprays to reduce drift. It may be used with water carriers or oil-in-water emulsions. **Lo-Drift is not designed for use with oil carriers**, but a special oil-soluble form may be available in the near future. Lo-Drift differs from Vistik and Dacagin in that it: (1) is a liquid formulation, (2) requires a wetting agent to activate the polymer, and (3) can be applied through conventional spray equipment.

For aerial application, 4 to 8 ounces of Lo-Drift are added per 100 gallons of spray solution. The thickened mixture has a viscosity similar to that of mineral oil and is easily pumped at the recommended pressure of 30 p.s.i. Maximum drift control is obtained with either D-4, D-6, or D-8 nozzles without whirl plates; the nozzles directed back along the airstream at an angle not greater than 30 degrees from horizontal. All screens

in the spray system should be 50-mesh or larger.

The recommended mixing procedure is:

1. Add herbicide to water in nurse tank.
2. Agitate thoroughly.
3. With continued agitation, add 8 ounces of surfactant, such as X-77, per 100 gallons of spray solution.
4. Shake Lo-Drift container for at least 1 minute, then add required amount of Lo-Drift while continuing agitation of the spray mixture.
5. Continue agitation of the spray mixture for several minutes until the spray mixture becomes viscous. After the spray thickens, reduce agitation rate to provide a continual gentle mixing that will maintain viscosity with a minimum of shear degradation.

Some herbicidal formulations do not require additional surfactant, and step 3 (above) may be omitted. Amchem Products, Inc. provides a list of their formulations that do not require additional surfactant as well as of those that do.

When herbicides formulated by other manufacturers are used, mix a small test batch following directions for spray mixtures requiring additional surfactant. Although the added surfactant may not be needed, it will not affect the spray mixture and may improve wetting of foliage. If desired, a small test batch may also be prepared without additional surfactant to determine whether the additive is needed.

When spraying is completed, all tanks, lines, screens, and nozzles should be flushed with a water and detergent solution as soon as possible. Spray all rinse solutions on one of the treated areas. Measuring equipment should be cleaned with petroleum solvents or hot water. *Do not add water to Lo-Drift containers.*

Particulating Agents

In this publication, a distinction is made between thickening agents and particulating agents. Vistik and Dacagin are spray thickeners that are soluble in water and increase the viscosity of water carriers or the water phase of herbicidal sprays. In contrast, particulating agents are classified as granular polymers in which each granule imbibes the spray solution and swells to a limited size. Norbak (manufactured by The Dow Chemical Co.) is a particulating agent originally developed for use with Tordon 101 Mixture (amines of picloram and 2,4-D). Norbak also increases viscosity of spray solutions, but flow is in the form of imbibed granular particles. Thickened sprays, on the other hand, flow as viscous solutions or gels.

NORBAK

Norbak is a water swellable plastic polymer for herbicidal sprays (fig. 4). In an aqueous solution, each particle absorbs liquid and swells to a limited size. If sufficient Norbak is added to a spray mixture, almost all of the liquid phase may be taken up and immobilized in the swollen particles. When properly mixed, Norbak produces a thick mixture with a granular appearance. Each swollen polymer particle is essentially separate when sprayed. Such formulations are referred to as "particulate sprays" (Ekins et al. 1970).

Norbak is designed for use with water solutions of pesticides. **It does not give satisfactory drift control when used with oil or oil-in-water emulsion carriers.** It is especially useful with herbicides formulated as metallic salts and water soluble amine salts, but it can

also be used with ester formulations of phenoxy herbicides and wettable powders. With wettable powders, Norbak will imbibe only the water phase of the spray mixture.

Although mixing procedures are relatively simple, mixing tanks, pumps, and spray application equipment have certain requirements. Good agitation in the mixing tank is essential. All tanks must be provided with mechanical agitation, and openings in baffle plates of large tanks should be big enough to permit rapid passage of particulated spray between the tank sections. Agitation must be sufficiently vigorous to induce movement and blending of the mixture from all parts of the tank. The mixing tank should be equipped with a positive displacement vane, gear, roller, or piston pump. The tank should have a bottom outlet, and the pump should be mounted at or below the level of the tank bottom. Hoses and supply lines should be 1-1/2 inches or larger in inside diameter and as short as possible.

The recommended procedure for mixing Norbak sprays is:

1. Cleanse nurse tank of all oil and other herbicides.
2. Place one quarter of the required amount of water in the tank.
3. Start agitation and then slowly add the required amount of herbicide with continuous agitation. Mix thoroughly.
4. With continuous agitation, slowly add 6 to 12 pounds of Norbak for each 100 gallons of the final spray volume. Continue agitation for 3 to 5 minutes.
5. With continuous agitation, add the remaining three quarters of the water. Continue agitation for 3 to 5 minutes after all water is added.
6. Wait at least 10 minutes for proper swelling to occur before spraying.
7. Determine consistency of the spray mixture with a Dow consistency test funnel (fig. 7). Spray mixtures for helicopter application should take from 45 to 85 seconds to drain from the funnel. If the mixture is too thick, it may be thinned by adding more water. If an appreciable amount of water must be added, spray volume applied per acre should be proportionately increased.

Norbak sprays should be applied with either Dow's R-511 spray system or the modified R-511 system with short boom. The R-511 with its clustered nozzles should be used only on utility rights-of-way. The modified R-511 should be used in forest spraying and can also be used on rights-of-way. Spray nozzles should be standard diaphragm shut-off

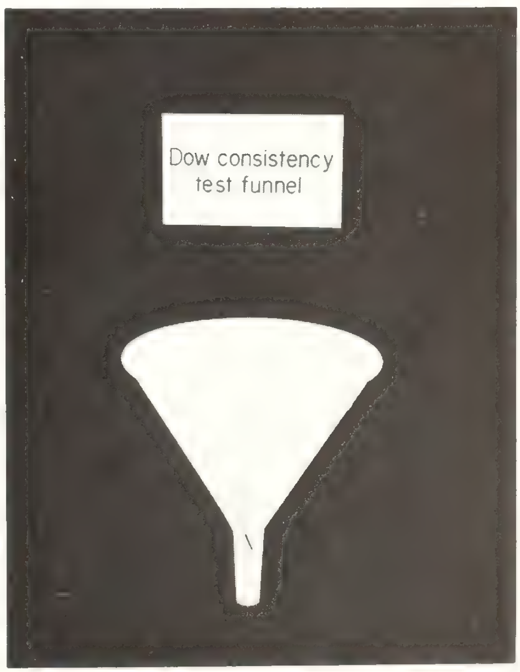

Figure 7.—Dow test funnel for determining consistency of Norbak-thickened sprays.

nozzles with flat-fan orifice tips or cone nozzles without inserts. Orifice diameter must be 0.04 inch or larger. Nozzle screens may be necessary with the smaller orifices. All screens should be 50-mesh or larger. Inside diameter of spray booms must be at least 1.20 inches, and pressure gauges should be mounted on the ends of the boom. Recommended spray pressure at the end of the boom is 20 p.s.i.

Foam Sprays

Foam-producing additives are the newest materials designed to increase viscosity and wetting properties of herbicidal sprays. Foam sprays are easier to transport, mix, and apply than invert emulsions or spray thickeners discussed earlier. Basic components of this system are: (1) a water soluble liquid surfactant containing the foaming agent, stabilizers, and wetting agents and (2) specially designed spray nozzles that mix air into the spray solution to create a foam (fig. 8). Minimal shearing of foam into fine droplets and good coverage can be achieved by orienting the aerial spray nozzles back along the airstream at a 30° angle from the horizontal.

Foaming agents are produced by several companies. Among these are Accutrol (marketed by Velsicol Chemical Corp.), Foamspray (LTV Aerospace Corp.), and Fomex (Colloidal Products Corp.). Each company sells suitable foam-generating nozzles or makes them available to applicators for a small handling fee. Special foam-producing nozzles have also been developed by Delavan Manufacturing Corporation and by Spraying Systems Company. Delavan nozzles are used with Fomex by Colloidal Products. Spraying Systems' FoamJet tips are interchangeable with their TeeJet tips. Boom pressures of 40 p.s.i. or greater are generally recommended for application of foam sprays.

Foaming agents produced by different

Figure 8.—Accutrol foam nozzles. The two white plastic nozzles are designed for aerial spraying: cone-topped nozzle produces finer droplets than the flat-topped nozzle.

companies vary in their chemical composition. Therefore, unless future research proves it unnecessary, foresters should **use only nozzles recommended by the manufacturer of the foaming agent** (i.e., Accutrol with Accutrol nozzles, Fomex with Delavan nozzles, etc.). The nozzles are designed to match the expansion ratio of the foaming agent.

Foaming agents may be used with water soluble herbicides, with oil-in-water emulsions, and with wettable powders. They act only upon the water phase of the spray mixture. **They cannot be used with pure oil carriers**. Foam sprays can be applied with conventional aerial spray equipment modified only by adding the special foam-producing nozzles.

Only small amounts of foaming agent are needed in herbicidal sprays. Recommended rates are 1/2 to 1 gallon per 100 gallons of spray. The lower rate is suitable for water carriers; 3 quarts to 1 gallon per 100 gallons of spray may be needed for oil-in-water emulsions containing 1/2 to 1 gallon of oil per 10 gallons of spray--a normal spray volume per acre in aerial application of herbicides on forest lands.

Foam sprays discharged from the nozzle are a frothy mixture containing widely varied sizes of air bubbles rather than a thick, heavy foam of uniform consistency. The expansion ratio of foam to water is in the range of 3:1 to 5:1. Each gallon of liquid spray forms 3 to 5 gallons of foam. The bubbles cling together to form large globules that fall in a sheetlike pattern beneath the helicopter (fig. 9). Stabilizing agents keep the foam from breaking down while falling from the nozzles to vegetation; wetting agents then allow the spray droplets to run together and spread over leaf surfaces.

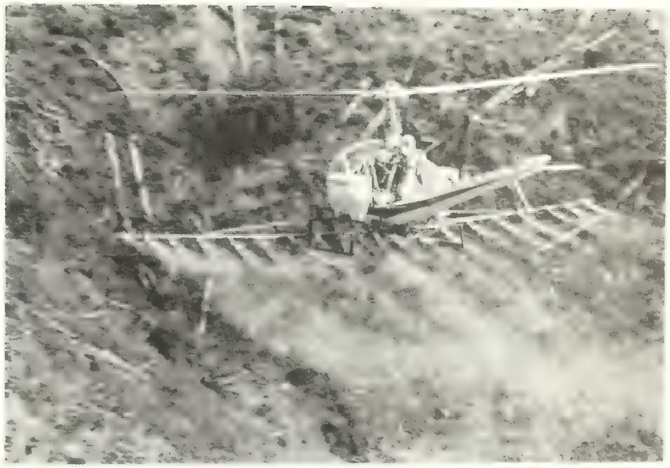

Figure 9.—Aerial application of an oil-in-water emulsion of 2,4,5-T as a foam spray during critical weather conditions: wind velocity about 5 m.p.h. and relative humidity near 50 percent. Note absence of whorls evident in figure 1.

Advantages **claimed** for foam sprays are that they:

1. Reduce drift,
2. Reduce evaporation in the air, and thus increase amounts of herbicide that reach vegetation in the treated area,
3. Increase adhesion of herbicides on foliage,
4. Reduce evaporation of herbicides from leaf surfaces,
5. Allow spraying at higher temperatures and lower relative humidity,
6. Are visible to pilots on return passes and thus reduce skips in application,
7. Hold fine solids uniformly suspended, and
8. Stabilize emulsions.

Mixing instructions vary. Velsicol recommends adding the foaming agent to the water phase of oil-in-water emulsions before adding the oil and herbicide; Colloidal Products Corp. recommends adding the foamer after all other ingredients are thoroughly mixed. Both methods are probably equally effective, but adding the foaming agent last is probably easier

in the field. In either case, after adding the foaming agent, the spray mixture should be agitated to thoroughly mix and dissolve it in the water phase of the carrier.

As with spray thickeners, mechanical agitation will provide the best mixing in nurse tanks. If bypass hydraulic agitation is used, it is important that the inlet to the nurse tank be kept below the liquid surface to minimize foaming. A bypass that splashes in from above will add air and cause foaming in the nurse tank. After adding the foaming agent, use only enough agitation to maintain dispersion of emulsions and prevent settling of wettable powders.

After spraying, equipment may be cleaned with water and detergent and then flushed with water. Apply this material and rinse water from herbicide containers on one of the treated areas to minimize environmental contamination.

Foaming agents are biodegradable and some manufacturers claim that they do not cause dermatitis. However, long exposure is not recommended, because **some foaming agents have a drying action on the skin**. Wet areas should be rinsed with water as soon as possible.

HERBICIDAL EFFECTIVENESS OF THICKENED SPRAYS

The possibility that herbicidal activity might be decreased in viscous sprays deserves consideration. Unfortunately, few studies have been carried out to determine the relative biological effectiveness of herbicides in thickened sprays vs. conventional carriers.

McKinlay et al. (1972) studied the effect of droplet size on phytotoxicity of of oil-soluble 2,4-D amines. Their results indicate that phytotoxicity is directly related to coverage--number of droplets per unit of plant surface area. Herbicidal effect increased as droplet size decreased. When compared with droplets 100 microns in diameter, equal spray volumes of 200 micron and 400 micron droplets required approximately three times and six times as much herbicide to obtain the same herbicidal effect. However, for a given droplet size, herbicidal activity could be increased equally well either by increasing the concentration or by increasing the number of droplets per unit area. Field application of these results would indicate that invert emulsions and thickened sprays producing larger droplet sizes would require either an increased amount of herbicide per acre or an increased volume of carrier to insure herbicidal effects equal to those obtained with conventional carriers that produce many more small droplets.

INVERT EMULSIONS

The consensus of research results is that invert emulsions of 2,4-D and 2,4,5-T esters are usually less effective in killing woody plants than equal amounts of herbicide applied in normal oil-in-water emulsions or oil carriers (Kirch et al. 1960, Darrow and Silker 1959, Phillips 1963, Brady et al. 1969). This agrees with observations of foresters in the Pacific Northwest. However, invert emulsions have proved a useful tool for insuring accurate placement of aerial sprays on utility rights-of-way.

VISTIK

The possibility that viscous Vistik-thickened sprays might be less effective than conventional sprays was considered by Suggitt (1965) and others. Although viscous sprays improve adhesion to

foliage, the higher viscosity also reduces spread and coverage on leaf surfaces. After observing the effects of thickened and conventional sprays of 2,4,5-T and 2,4,5-T/TCA herbicides on woody plants, Suggitt concluded that herbicidal properties of the viscous sprays were equivalent to those of conventional sprays. He stated that higher volumes are probably not required in foliage and stem spraying. Ekins et al. (1970) determined that Vistik did not reduce the herbicidal effect of paraquat, nor did it prevent amitrole-T from being washed from leaves of treated plants.

In field tests on the Siuslaw National Forest, Vistik-thickened sprays were less effective and more variable than unthickened sprays in defoliation of salmonberry (table 1). Neither treatment produced an acceptable degree of topkill. However, the sprays were applied in water carriers during late August, much too late for good results on this species. Neither spray caused any appreciable damage on young Douglas-firs averaging 2 to 3 feet in height.

DACAGIN

Dacagin was also compared to Vistik and Norbak as drift reduction adjuvants on field crops in Oregon (Ekins et al. 1970). None of the three adjuvants alone injured wheat, barley, or red clover. Like Vistik, Dacagin did not reduce the herbicidal effectiveness of paraquat nor prevent amitrole-T from being washed from leaf surfaces. It did, however, reduce vapor loss of a high volatile ester of 2,4-D from plant surfaces.

No studies are known where herbicidal effects of Dacagin-thickened sprays were compared with normal carriers on woody plants. However, Dacagin-thickened sprays have been applied on shrubs and weed trees in National Forests in northern California. After observation, foresters were pleased with drift reduction achieved with Dacagin and were of the opinion that Dacagin-thickened sprays were as effective as similar treatments in oil-in-water emulsions or water carriers.[1]

[1] Personal communication from M. Knight, Region 5, Forest Service, U.S. Department of Agriculture.

Table 1.--*Comparison of Vistik-thickened vs. unthickened sprays of amitrole-T in water carriers on salmonberry and young Douglas-firs*[1]

Area	Salmonberry				Douglas-fir			
	Unthickened		With Vistik		Unthickened		With Vistik	
	Defoliation	Topkill	Defoliation	Topkill	Defoliation	Topkill	Defoliation	Topkill
	Percent							
1	87	20	27	11	6	2	4	0
2	90	11	66	14	4	0	4	0
3	99	10	42	16	5	0	12	2
Means	92	14	45	14	5	1	7	1

[1] Based on examination of 40 plants of each species per area, 12 months after treatment.

LO-DRIFT

Since Lo-Drift is a new product, only limited data are available concerning its effect on herbicidal activity. Information provided by Amchem Products, Inc. indicates that Lo-Drift did not change the effectiveness of six different herbicidal formulations on sorghum, soybeans, alfalfa, or cucumbers. No such information is yet available for woody plants.

NORBAK

Byrd and Reimer (1966) found no reduction in effect of picloram solutions particulated with Norbak. However, Ekins et al. (1970) state that Norbak did reduce the effect or paraquat on field crops. They suggest that this reduction may have resulted from insufficient coverage of plant surfaces by the spray solution. Norbak markedly reduced the number of droplets in the spray swath, and fewer droplets contacted plant surfaces.

The reduction in number of droplets detected by Ekins may have resulted from clumping or aggregation of Norbak particles during application. Furthermore, it seems possible that herbicides absorbed within Norbak particles may not be readily available for absorption from the particles on leaf surfaces. Both effects could seriously reduce the activity of herbicides in low volume aerial sprays on forest-land brush species and weed trees.

Norbak-thickened sprays were compared with invert emulsions in an early June aerial application of picloram plus 2,4-D on the Siuslaw National Forest.[2] Norbak was used with triisopropanolamine salts of both herbicides in a water carrier; the invert emulsion contained a potassium salt of picloram and a low volatile ester of 2,4-D. The herbicides were tested as preburn desiccants. Evaluation before the areas were burned 3 months later indicated that both formulations were equally effective on salmonberry, thimbleberry, vine maple, and swordfern. The Norbak-vs.-invert comparison, however, must be considered with reservation, since each contained different forms of the two herbicides. Increasing spray volume of the invert carrier from 10 to 15 gallons did not increase either defoliation or topkill during the 3-month period after treatment. Unfortunately, no comparison was possible with similar forms of the two herbicides in conventional carriers.

FOAM SPRAYS

Foam sprays are a relatively recent innovation as carriers for herbicides. Experimental data concerning the influence of foam carriers on effectiveness of herbicides are as yet extremely limited and inconclusive. However, observation of both ground and aerial applications on crop and weed species indicates: (1) liquid spray volumes for foam application must be about the same as volumes used with conventional carriers, and (2) herbicidal effects are similar to those obtained with equal rates of chemical in conventional carriers, although phytotoxicity of some herbicides may be increased on sensitive plants.

Foam carriers were used in early August 1972 foliar sprays on red alder, salmonberry, and thimbleberry in the Siuslaw National Forest. Coarse Accutrol nozzles were used for this application. In the opinion of foresters, based upon observation 2-1/2 months after application, foam carriers were producing results at least equal to those obtainable

[2] Special formulations were provided by L. E. Warren of The Dow Chemical Company. This cooperation is appreciated.

with similar rates of herbicide in oil-in-water emulsions. The foam carrier was used with an emulsion containing one-half gallon of No. 2 fuel oil per acre. Liquid spray volume was 10 gallons per acre as usual.

Observations of early July foliar applications on the same species in the Elliott State Forest near Reedsport, Oregon, also indicate that effects of herbicides in foam carriers were equal to those obtained with normal carriers. Foam sprays were used with emulsion carriers along buffer strips near streams and other ecologically sensitive areas. Main portions of the cuttings were treated with identical sprays, equipment, and nozzles; but the foaming agent was not used.

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1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Development and evaluation of alternative methods and levels of resource management.
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USDA Forest Service General Technical Report PNW-4

UMAN BEHAVIOR ASPECTS OF SH AND WILDLIFE CONSERVATION

AN ANNOTATED BIBLIOGRAPHY

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Abstract

The bibliography covers nonbiological or human behavior aspects of fish and wildlife conservation including sportsman characteristics, safety, law enforcement, professional and sportsman education, nonconsumptive uses, economics, and history. There are 995 references from 218 different sources. Also included are a list of reference sources used, an author index, and keywords, along with a keyword index.

KEYWORDS: Recreation, wildlife, hunting, fishing, bibliography.

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General Technical Report PNW-4

HUMAN BEHAVIOR ASPECTS OF FISH AND WILDLIFE CONSERVATION

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1973

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Robert E. Buckman, Director

Portland, Oregon

CONTENTS

INTRODUCTION

This annotated bibliography was compiled to aid students, teachers, researchers, conservationists, and managers seeking literature on nonbiological or human behavior aspects of fish and wildlife conservation. Examples of specific topics included are: sportsman characteristics, preferences, opinions, and attitudes; economic impact of sportsmen and wildlife; hunter safety and law enforcement; the wildlife profession, education, and administration; nonconsumptive uses of wildlife; and history.

The authors were impressed by the great number and diversity of articles on human behavior aspects of fish and wildlife but dismayed at the lack of rigorous research on the subject.[1] The following table presents a categorized summary of the 218 different reference sources in which the 995 articles listed in this bibliography were found. This overview of articles and their sources suggests substantial concern with people problems by managers, reflected in talks and papers to conferences and by articles in their department-sponsored magazines.

Reference Type	*Number*	*Percent*
Conference proceedings	338	34
State Game-Conservation Department periodicals	142	14
Scientific journals	148	15
Conservation, trade journals, and outdoor magazines	122	12
Ph.D. dissertations, Master's theses	113	11
Federal-State-university-foundation sponsored reports	102	10
Other	30	3
	995	99

1/ *For an earlier assessment of human behavior-wildlife literature see: Hendee, John C., and Dale R. Potter. 1971. Human behavior and wildlife management: needed research. 36th North Am. Wildl. Nat. Resour. Conf. Proc. 36: 383-396.*

We hope this compilation of annotated references to the literature will provide needed impetus and information to increase the amount and quality of research and professional debate about human behavior aspects of fish and wildlife conservation.

The abstracts accompanying most of the articles attempt to describe substantive content and conclusions rather than describing what the article is about.

This bibliography has several features to aid the user. (1) "Abbreviations and Frequency of Referenced Material" gives the exact abbreviations for all journals, magazines, and other sources cited in the bibliography and the number of articles referenced. This list reflects the great diversity of sources in which wildlife conservation topics are covered. (2) The section "Other Bibliographical Sources Used to Locate References" may be useful to readers seeking additional wildlife or natural resource materials. (3) The "Author Index" lists in alphabetical order all of the authors included in the bibliography; this includes all junior authors in addition to senior authors. (4) The keywords with each reference and the "Keyword Index" will aid the user in two ways. The index is used like any book index--you look up specific topics of interest and go directly to the numbered references on that topic. In addition, the keywords listed with each reference give a quick review of topics covered in that document and may include some topics not mentioned in the annotation.

We apologize in advance for any injustices, inaccuracies, or omissions that are sure to result from the review of such a massive amount of material. Readers are urged to correspond with the authors regarding errors contained in this bibliography. If appropriate references have been omitted, we would appreciate receiving a copy or knowing of their title and source. Our objective is the most complete collection of annotated references possible on the subject, "human behavior aspects of fish and wildlife conservation." These should be sent to:

Wildland Recreation Research
Pacific Northwest Forest and Range
Experiment Station
4507 University Way N.E.
Seattle, Washington 98105

Persons desiring publications included in this bibliography should go to the reference source cited or write to the agency which sponsored the publication. Neither the Pacific Northwest Forest and Range Experiment Station nor the authors can provide copies of any references listed in this bibliography, except material published by the Station.

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ABBREVIATIONS AND FREQUENCY OF REFERENCED MATERIAL[2]

Abbreviation	*Number of References Included*	*Source*
Am. Assoc. Advan. Sci. Symp.	1	American Association for the Advancement of Science Symposium
Am. Fish. Soc. Trans.	3	American Fisheries Society Transactions
Am. For.	34	American Forests
Am. For. For. Life	1	American Forests and Forest Life
Am. Nat. Assoc. Wildl. Manage. Inst.	1	American Nature Association and Wildlife Management Institute
Ariz. Fish Game Dep.	1	Arizona Fish and Game Department
Ariz. Game Fish Comm. Fed. Aid Wildl. Restoration Div.	1	Arizona Game and Fish Commission, Federal Aid in Wildlife Restoration Division
Audubon	2	Audubon
Auk	1	The Auk
Biometrics	1	Biometrics
Bobbs-Merrill Co., Inc. Inter-Univ. Case Prog.	1	The Bobbs-Merrill Company, Incorporated, Inter-University Case Program
Brigham Young Univ. Pac. Southwest. For. Range Exp. Stn.	1	Brigham Young University and Pacific Southwestern Forest and Range Experiment Station
Bull. Ecol. Soc. Am.	1	Bulletin of Ecological Society of America
Bur. Outdoor Rec.	1	Bureau of Outdoor Recreation
Bur. Res. State Wis. Dep. Nat. Resour.	1	Bureau of Research, State of Wisconsin Department of Natural Resources
Bus. Week	1	Business Week
Calif. Fish Game	19	California Fish and Game

2/ *Colleges and universities represented by theses and dissertations are listed separately at the end of this list.*

Can. Audubon	1	Canadian Audubon
Can. Raptor Soc.	1	Canadian Raptor Society
Colo. Div. Game Fish Parks	2	Colorado Division of Game, Fish and Parks
Colo. Outdoors	3	Colorado Outdoors
Colo. State Univ. Dep. Econ.	2	Colorado State University, Department of Economics
Conf. Am. Game Trans.	5	Conference American Game Transactions
Conf. Int. Assoc. Game Fish Conserv. Comm. Proc.	74	Conference International Association of Game and Fish Conservation Commission Proceedings
Conf. Int. Union Conserv. Nat. Nat. Resour.	1	Conference of the International Union for Conservation of Nature and Natural Resources
Conf. Natl. Acad. Sci. Res. Counc. Arctic Inst. North Am.	1	Conference of the National Academy of Science Research Council, Arctic Institute of North America
Conf. North Am. Wildl. Nat. Resour. Trans.	27	Conference North American Wildlife and Natural Resources Transactions
Conf. North Am. Wildl. Trans.	81	Conference North American Wildlife Transactions
Conf. Northeast Wildl. Trans.	2	Conference Northeast Wildlife Transactions
Conf. Southeast, Assoc. Game Fish Comm. Proc.	51	Conference Southeastern Association of Game and Fish Commissioners Proceedings
Conf. West. Agric. Econ. Res. Counc. Proc.	1	Conference Western Agricultural Economics Research Council Proceedings
Conf. West. Assoc. State Game Fish Comm. Proc.	88	Conference Western Association of State Game and Fish Commissioners Proceedings
Congr. Int. Union Game Biol. Trans.	2	Congress of the International Union of Game Biologists Transactions
Conservationist	3	The Conservationist
Conserv. Volunteer	1	Conservation Volunteer

Dep. Fish. For. Ottawa Can.	1	Department of Fisheries and Forestry, Ottawa, Canada
Dep. Fish Game, State Calif.	1	Department of Fish and Game, State of California
Dep. Rec. Conserv. Fish Wildl. Branch B.C.	1	Department of Recreation and Conservation, Fish and Wildlife Branch, British Columbia
Down East	1	Down East
Dubuque, Iowa: William C. Brown Co.	1	Dubuque, Iowa: William C. Brown Company
East Alton, Ill.: Conserv. Dep. Winchester West. Div., Olin Corp.	3	East Alton, Illinois: Conservation Department, Winchester Western Division, Olin Corporation
Ecology	1	Ecology
Field Stream	11	Field and Stream
Fla. Wildl.	24	Florida Wildlife
For. Chron.	1	The Forestry Chronicle
For. Q.	4	Forestry Quarterly
Garden Club Am. Bull.	1	Garden Club of America Bulletin
Guns Hunting	1	Guns and Hunting
Idaho Wildl. Rev.	2	Idaho Wildlife Review
Int. Conf. Conserv. Nat. Nat. Resour. Proc.	1	International Conference for Conservation of Nature and Natural Resources Proceedings
Iowa State Coll. J. Sci.	1	Iowa State College Journal of Science
Izaak Walton League Outdoor Am.	1	Izaak Walton League, Outdoor America
Izaak Walton Mag.	1	Izaak Walton Magazine
J. Environ. Educ.	7	The Journal of Environmental Education
J. For.	29	Journal of Forestry
J. Leisure Res.	5	Journal of Leisure Research
J. Mammology	1	Journal of Mammology

J. Range Manage.	2	Journal of Range Management
J. Soil Water Conserv.	4	Journal of Soil and Water Conservation
J. Wildl. Manage.	72	Journal of Wildlife Management
J. Wildl. Program Manage.	1	Journal of Wildlife Program Management
La. Conserv.	1	Louisiana Conservationist
Land Econ.	1	Land Economics
Life	1	Life
Life Sci.	1	Life Science
London: Adam and Charles Black Ltd.	1	London: Adam and Charles Black, Limited
London: Ernest Benn Ltd.	1	London: Ernest Benn, Limited
Mich. Academician	1	Michigan Academician
Mich. Conserv.	5	Michigan Conservationists
Mich. Dep. Conserv.	5	Michigan Department of Conservation
Mich. Dep. Nat. Resour.	6	Michigan Department of Natural Resources
Minn. Conserv. Volunteer	1	Minnesota Conservation Volunteer
Mont. State Univ.	1	Montana State University
Natl. Rev. (Br.)	1	National Review (British)
Natl. Shooting Sports Found.	2	National Shooting Sports Foundation
Natl. Wildl.	11	National Wildlife
Nat. Resour. J.	2	National Resources Journal
Naturalist	2	Naturalist
N. Brunswick, N.J.: Rutgers Univ. Press	1	New Brunswick, New Jersey: Rutgers University Press
N.D. Outdoors	2	North Dakota Outdoors
Nev. Outdoors Wildl. Rev.	1	Nevada Outdoors and Wildlife Review
New York: Appleton-Century-Crofts Inc.	2	New York: Appleton-Century-Crofts, Incorporated

New York: Boone and Crockett Club	1	New York: Boone and Crockett Club
New York: Charles Scribner's Sons	2	New York: Charles Scribner's Sons
New York: Funk and Wagnalls Co.	1	New York: Funk and Wagnalls Company
New York: Macmillan Co.	2	New York: The Macmillan Company
N.H. Fish Game Dep.	2	New Hampshire Fish and Game Department
N.M. Dep. Game Fish	1	New Mexico Department of Game and Fish
North Am. Game Breeders Assoc. Conv.	1	North American Game Breeders Association Convention
Northwest Sci.	1	Northwest Science
N.Y. Fish Game J.	9	New York Fish and Game Journal
N.Y. Hist. Soc. Q.	1	New York Historical Society Quarterly
N.Y. State Conserv.	13	The New York State Conservationist
Ohio Agric. Exp. Stn.	1	Ohio Agricultural Experiment Station
Okla. State Univ.	1	Oklahoma State University
Edinburgh and London: Oliver and Boyd Ltd.	1	Edinburgh and London: Oliver and Boyd, Limited
Oreg. State Game Comm. Bull.	1	Oregon State Game Commission Bulletin
ORRRC	2	Outdoor Recreation Resources Review Commission
Outdoor Calif.	1	Outdoor California
Outdoor Life	8	Outdoor Life
Outdoor W.Va.	1	Outdoor West Virginia
Pac. Northwest River Basins Comm.	2	Pacific Northwest River Basins Commission
Parks Rec.	5	Parks and Recreation
Pa. State Agric. Exp. Stn.	2	Pennsylvania State Agriculture Experiment Station
Pa. State Univ. Dep. Agric. Rural Sociol.	1	Pennsylvania State University, Department of Agriculture and Rural Sociology

Philadelphia: J. B. Lippincott Co.	1	Philadelphia: J. B. Lippincott Company
Public Land Law Rev. Comm.	1	Public Land Law Review Commission
Purdue Univ. Agric. Exp. Stn.	1	Purdue University Agriculture Experiment Station
Reading, Mass: Addison-Wesley Publ. Co., Inc.	1	Reading, Massachusetts: Addison-Wesley Publishing Company, Incorporated
Recreation Symp. Proc. USDA For. Serv. Northeast. For. Exp. Stn.	1	Recreation Symposium Proceedings, United States Department of Agriculture, Forest Service, Northeastern Forest Experiment Station
Resour. Future, Inc.	1	Resources for the Future, Incorporated
Rod Gun	3	Rod and Gun
Rod Gun Can.	2	Rod and Gun in Canada
Rural Sociol.	1	Rural Sociology
Rutgers Univ. Bur. Econ. Res.	1	Rutgers University, Bureau of Economic Research
Sat. Evening Post	4	Saturday Evening Post
Sat. Rev. Lit.	1	The Saturday Review of Literature
Sci. Counc. Can.	1	Science Council of Canada
Science	1	Science
S.D. Conserv. Dig.	1	South Dakota Conservation Digest
S.D. State Univ. Agric. Exp. Stn.	1	South Dakota State University, Agriculture Experiment Station
Shooting Sports Assoc. Inc.	1	Shooting Sports Associated, Incorporated
Soc. Am. For. Proc.	1	Society of American Foresters Proceedings
Soil Conserv.	2	Soil Conservation
South. Ill. Univ. Dep. For.	1	Southern Illinois University, Department of Forestry
Spectator	1	Spectator
Sportfishing	1	Sportfishing

Sporting Arms Manuf. Inst.	1	Sporting Arms and Manufacturing Institute
Sports Illus.	15	Sports Illustrated
TAM Archery World	1	TAM Archery World
Tex. Game Fish.	19	Texas Game and Fisheries
Univ. Ariz. Bur. Bus. Public Res.	1	University of Arizona, Bureau of Business and Public Research
Univ. Ariz. Coll. Bus. Public Adm.	1	University of Arizona, College of Business and Public Administration
Univ. B.C.	1	University of British Columbia
Univ. Ky. Water Resour. Inst.	1	University of Kentucky, Water Resources Institute
Univ. Mass. Agric. Exp. Stn.	1	University of Massachusetts, Agriculture Experiment Station
Univ. Md. Agric. Exp. Stn.	1	University of Maryland, Agriculture Experiment Station
Univ. Mo. Agric. Exp. Stn. Resour. Dev. Econ. Div.	1	University of Missouri, Agriculture Experiment Station and Resource Development, Economics Division
Univ. Nevada Agric. Exp. Stn.	1	University of Nevada, Agriculture Experiment Station
Univ. Nevada Max C. Fleischmann Coll. Agric.	1	University of Nevada, Max C. Fleishmann College of Agriculture
Univ. N.M. Bur. Bus. Res.	1	University of New Mexico, Bureau of Business Research
Univ. R.I. Agric. Exp. Stn.	3	University of Rhode Island, Agriculture Experiment Station
Univ. Utah Bur. Econ. Bus. Res.	1	University of Utah, Bureau of Economic and Business Research
Univ. Vt. Agric. Exp. Stn.	1	University of Vermont, Agriculture Experiment Station
Univ. Wis. Bur. Bus. Res. Serv.	2	University of Wisconsin, Bureau of Business Research and Service
Univ. Wis. Coll. Agric. Life Sci.	2	University of Wisconsin, College of Agriculture and Life Science
U.S. Congr. 1st Sess.	4	United States Congress, 1st Session

U.S. Congr. 2nd Sess.	1	United States Congress, 2nd Session
USDA Biol. Surv. Bull.	1	United States Department of Agriculture, Biological Survey Bulletin
USDA Econ. Res. Serv.	1	United States Department of Agriculture, Economic Research Service
USDA For. Serv.	2	United States Department of Agriculture, Forest Service
USDA For. Serv. North Cent. For. Range Exp. Stn.	2	United States Department of Agriculture, Forest Service, North Central Forest and Range Experiment Station
USDA For. Serv. Southeast. For. Exp. Stn.	3	United States Department of Agriculture, Forest Service, Southeastern Forest Experiment Station
USDA For. Serv. Pac. Southwest For. Range Exp. Stn.	2	United States Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station
USDI Bur. Sport Fish. Wildl. Serv.	10	United States Department of the Interior, Bureau of Sport Fisheries and Wildlife Service
Utah Sci.	1	Utah Science
Utah State Univ. Agric. Exp. Stn.	1	Utah State University, Agriculture Experiment Station
Utah State Univ. Inst. Soc. Sci. Res. Nat. Resour.	1	Utah State University, The Institute for Social Science Research on Natural Resources
Va. Polytech. Inst. Dep. For. Wildl. Res.	2	Virginia Polytechnic Institute, Department of Forestry and Wildlife Research
Va. Wildl.	4	Virginia Wildlife
Wash. Dep. Fish.	1	Washington Department of Fisheries
Washington, D.C.: Wildl. Soc.	1	Washington, D.C.: The Wildlife Society
Wash. State Coll. Econ. Bus. Res.	2	Washington State, College of Economics Business Research
Wash. State Game Bull.	1	Washington State Game Bulletin
Wild Cascades	1	The Wild Cascades (Northwest Section of Sierra Club)

Wildl. Manage. Inst.	2	Wildlife Management Institute
Wildl. N.C.	3	Wildlife of North Carolina
Wildl. Soc. News	2	Wildlife Society News
Wis. Conserv. Bull.	40	Wisconsin Conservation Bulletin
Wis. Conserv. Dep.	4	Wisconsin Conservation Department
Wyo. Wildl.	2	Wyoming Wildlife

College and University Sources for Theses and Dissertations

Auburn Univ.	1	Auburn University
Colo. Agric. Mech. Coll. Colo. State Univ.	2	Colorado Agricultural and Mechanical College, Colorado State University
Colo. State Univ.	1	Colorado State University
Columbia Univ.	1	Columbia University
Cornell Univ.	5	Cornell University
George Peabody Coll. Teach.	1	George Peabody College for Teachers
Iowa State Univ.	3	Iowa State University
Johns Hopkins Univ.	1	Johns Hopkins University
Kans. State Univ.	1	Kansas State University
La. State Univ.	3	Louisiana State University
Mankato State Teach. Coll.	1	Mankato State Teachers College
Mich. State Univ.	7	Michigan State University
Mont. State Univ.	2	Montana State University
N.C. State Coll.	1	North Carolina State College
Northwest. Univ.	1	Northwestern University
N.Y. Univ.	1	New York University
Ohio State Univ.	3	Ohio State University
Oreg. State Coll.	7	Oregon State College
Oreg. State Univ.	4	Oregon State University

Pa. State Univ.	2	Pennsylvania State University
Princeton Univ.	1	Princeton University
South. Ill. Univ.	3	Southern Illinois University
Springfield Coll.	1	Springfield College
Syracuse Univ.	2	Syracuse University
Tex. A&M Univ.	2	Texas Agricultural and Mechanical University
UCLA	1	University of California at Los Angeles
Univ. Ala.	1	University of Alabama
Univ. Alaska	1	University of Alaska
Univ. Calif.	1	University of California
Univ. Colo.	1	University of Colorado
Univ. Conn.	1	University of Connecticut
Univ. Fla.	1	University of Florida
Univ. Ga.	1	University of Georgia
Univ. Idaho	1	University of Idaho
Univ. Maine	2	University of Maine
Univ. Mass.	5	University of Massachusetts
Univ. Mich.	12	University of Michigan
Univ. Minn.	2	University of Minnesota
Univ. Mo.	2	University of Missouri
Univ. N.C.	1	University of North Carolina
Univ. Okla.	1	University of Oklahoma
Univ. Tex.	1	University of Texas
Univ. Wash.	4	University of Washington
Univ. Wis.	4	University of Wisconsin
Univ. Wyo.	2	University of Wyoming
Utah State Univ.	8	Utah State University
Va. Polytech. Inst.	3	Virginia Polytechnic Institute

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1969. A selected bibliography of forest management-wildlife management for southeast Alaska. Publ. No. 3, 19 p. Sch. Agric. South. Ill. Univ.

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1962. Forestry theses accepted by colleges and universities in the United States, supplement July 1960-June 1961, including additions for 1915-June 1960. Forest Sci. 8(3): 309-320.

——— 1963. Forestry theses accepted by colleges and universities in the United States, supplement July 1961-June 1962, including additions for 1955-June 1961. Forest Sci. 9(3): 372-384.

——— 1964. Forestry theses accepted by colleges and universities in the United States, supplement July 1962-June 1963, including additions for 1933-June 1962. Forest Sci. 10(3): 371-384.

——— 1965. Forestry theses accepted by colleges and universities in the United States, supplement July 1963-June 1964, including additions for 1950-June 1963. Forest Sci. 11(2): 244-256.

——— 1966. Forestry theses accepted by colleges and universities in the United States, supplement July 1964-June 1965, including additions for previous years. Forest Sci. 12(2): 241-256.

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Timmer, V., B. Bradbury, and G. F. Weetman
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Waldron, Rodney K.
1960. Theses and dissertations, 1943-1959. Bibliogr. Ser. No. 6, 139 p. Oreg. State Coll.

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1. Abbey, Edward
   1970. Let us now praise mountain lions. Life 68(9): 52B-58, illus.

   Ignorance and mythology surround the mountain lion; he is hunted, trapped, poisoned, and, in Arizona, bountied because a few domestic animals occasionally fall prey. Predator control programs "eliminate all the wildlife except the deer, which are reserved for the licensed deer slayer." Wildlife managers are in the middle between lion preservationists and livestock owners and hunter groups favoring control of all "varmints." Many social and biological questions important to the survival of the mountain lions are raised.

   KEYWORDS: Antihunting, predator.

2. Abramson, Norman J.
   1962. Estimating the number of angling license purchasers. Calif. Fish Game 48(4): 253-255.

   In 1961 an estimated 118,070 (ratio of 0.875) persons purchased 134,936 special California angling licenses. Approximate standard errors of the number of purchasers and the ratio are 2,305 and 0.017, respectively. Estimates were obtained from a random sample of 7,493 license stubs.

   KEYWORDS: Research methods, fishing, California.

3. _________ and Catherine L. Berude
   1969. Distribution of California angling effort in 1968. Calif. Fish Game 55(4): 260-264.

   A post-card survey of licensed anglers showed the distribution of 1968 sport fishing effort in ocean waters, fresh waters, and the waters of San Francisco Bay and the Sacramento-San Joaquin Delta. Estimated percentages of total angler-days spent in these three water categories are 25.2, 64.2, and 10.6, respectively. Proportions of licensees fishing in each type of water are estimated at 0.436, 0.747, and 0.167, although the proportions of anglers fishing exclusively in the particular water category are 0.111, 0.382, and 0.017. An estimated 10 percent of all licensees did not fish. Survey results differ significantly from 1961 estimates.

   KEYWORDS: Fishing, crowding, California.

4. Acklen, Colonel
   1922. Federal migratory bird law. 14th Int. Assoc. Game Fish Conserv. Comm. Proc. 14: 53-58.

   Administrators should regulate and protect birds before catering to the pleasure of the shooter. They must protect vanishing game from aliens and market hunters through respect for the law and enforcement of it.

   KEYWORDS: Management, legislation.

5. Adams, Charles C.
   1924. Relation of wild life to recreation in forests and parks. 68th U.S. Congr. 1st Sess. Senate Doc. No. 151: 29-32.

The role of wildlife research and the development and execution of public policies are discussed.

KEYWORDS: Administration, research needs, historical value.

6. ________
1925. The conservation of predatory mammals. J. Mammology 6: 83-96.

Scientific, educational, social, and economic values of predators and methods of conservation and policies for management are mentioned.

KEYWORDS: Historical value, predator, conservation, economics, benefits.

7. ________
1926. The fundamentals of cooperation among wild life agencies. 69th U.S. Congr. 1st Sess. Senate Doc. No. 117: 66-70.

Techniques for recognizing the major wildlife interest groups and for formulating and executing public wildlife policies are discussed.

KEYWORDS: Administration

8. Adams, Harry E.
1938. Deer census and kill records of the Lake States. 3d Conf. North Am. Wildl. Trans., p. 287-295, illus.

For 4 years, checking stations were maintained at the forest boundaries on all main roads to obtain information on residence of hunters, number of days hunted, number and sex of deer shot, and opinions as to the trend of the deer population. Average acres of hunting territory per hunter decreased from 150 in 1934 to 115 in 1937. No correlation was found between hunting success and legal restrictions.

KEYWORDS: Harvest statistics, management, big game, surveys.

9. Adams, Kramer A.
1956. Multiple use on private lands. Am. For. 62(8): 14-15, 58-59, illus.

Hunter damage to private property such as from fires, vehicles, theft, vandalism, and trespassing is discussed. More hunter education and control and the opening of more private lands to recreation are suggested to correct the public's misconception of "multiple use."

KEYWORDS: Landowner-private, law violation, resource use.

10. Adams, William H. Jr.
1958. On the status of "wildlife management" as a scientific profession. 12th Conf. Southeast. Assoc. Game Fish Comm. Proc. 12: 275-279.

KEYWORDS: Profession, management, education, historical value.

11. Adams, Wm. C.
1932. Uniform non-resident licenses for all States. 24th Int. Assoc. Game Fish Conserv. Comm. Proc. 24: 41-46.

Uniform non-resident hunting and fishing fees are needed to force the sportsman to pay for his privileges. States that have more to offer in game opportunities should set a higher fee. Nationally the license fee is

not predicated on what the privilege is worth but on political considerations or the state of public sentiment.

KEYWORDS: License fee, fishing.

12. Albrecht, James Conrad
1965. The recreation resources of the Malheur National Wildlife Refuge. M.S. thesis, Oreg. State Univ., 112 p., illus.

This thesis purports to examine and evaluate, through library research and personal interviews, the resources of the Malheur National Wildlife Refuge with respect to current and potential use for recreation. The refuge system and its financing are discussed, sections covering the Malheur Refuge are purely descriptive in nature. (The major value of this thesis is the collection of information under one cover. Bibliography, 73.)

KEYWORDS: Refuge, non-consumptive use.

13. Albright, H. M., and T. G. Joselin
1930. The drift of the elk. Sat. Evening Post 202(52): 41-42, 44, 46, 138, illus.

The plight of Montana and Wyoming elk is outlined. They face possible extinction through starvation and over-hunting. Conservation movement and congressional action are reviewed.

KEYWORDS: Big game, conservation, legislation, historical value.

14. Allen, Dorothy E.
1961. The legacy of man and beaver in Michigan. M.S. thesis, Univ. Mich.

Restricted to Univ. of Mich. campus use.

KEYWORDS: Michigan, small game.

15. Allen, Durward L.
1962. Our wildlife legacy. (Rev.) 422 p., illus. New York: Funk & Wagnalls Co.

Of particular interest are chapters 17, "Biopolitics," and 18, "We'll call it yours and mine." Chapter 17 deals with State legislatures, game departments, and public opinion in decision making. Chapter 18 tells about properties and rights held in common which could be lost to hunters as pressure grows unless they see clearly and act quickly.

KEYWORDS: Politics, Federal-State jurisdiction.

16. ________
1972. The need for a new North American wildlife policy. 37th Conf. North Am. Wildl. Nat. Resour. Trans., 7 p.

This article has an historical perspective of the national policy of wildlife conservation and restoration formed in 1930. A new wildlife and human population policy must be integrated to reflect changed values and attitudes. Unless this is done, future populations will not be able to enjoy wildlife and the environment. There is evidence of a refinement in the public's taste in favor of more sporting methods of hunting, fishing, and non-consumptive use. Bow hunting and bird watching are examples. Problems of the past still exist and new ones have arisen, including

compensation for landowners for producing wildlife for public use, abuse of public lands and wildlife by special interests, State and Federal jurisdictional disputes, custodial obligation of non-game species, water and habitat destruction, off-trail vehicles, and finally human population growth. A population policy of zero growth and then progressive reduction of human numbers is needed.

KEYWORDS: Administration, historical value.

17. Amidon, Paul H.
1968. New York deer hunters: A comparison of deer law violators and non-violators. M.S. thesis, Syracuse Univ., 143 p., illus.

A sample of 150 convicted game violators (50 serious, 50 safety, and 50 miscellaneous violators) and 150 assumed nonviolators was drawn from each of four management areas. A mail questionnaire was pretested and then sent to 1,200 hunters, yielding a total usable response of 58.7 percent after two followup mailings. Nonrespondents were not investigated. Comparisons indicated generally no significant difference between violators and nonviolators for amount of time spent hunting. The party permit system was judged a good method for harvesting surplus deer, "hunting pressure was about right," and hunting regulations were "not too restrictive." Regulations were considered too much directed at the less important aspects of hunting. Reasons for illegal kill were for tangible benefits such as years of hunting experience, hunting success as perceived by the hunters, investment in equipment, and income. The deer killed per year of hunting experience was significantly higher for violators in three of the four areas studied. Characteristics of five New York deer management areas show that the effects of deer law violators are not uniform throughout the State. In one area illegal kill limits the size of a herd on a range which could support more deer, while in another area an adequate deer harvest is not obtained annually even when illegal kill is taken into consideration. (Questionnaire is included. Literature cited, 26.)

KEYWORDS: New York, law violation, characteristics, big game, research methods.

18. Andrews, Wade H., Alten B. Davis, Kenneth S. Lyon, Gary E. Madsen, R. Welling Roskelley, and Bruce L. Brower
1972. Identification and measurement of quality of life elements in planning for water resources development: An exploratory study. Utah State Univ. Inst. Soc. Sci. Res. Nat. Resour., Res. Rep. No. 2. 184 p., illus.

An interview provided the main bulk of data on income distribution, work, leisure, esthetics, level of living, and water resources. Rural and urban populations were randomly sampled in each Utah county. Fishing was used as a means to measure water resource enjoyment. Fish enjoyment factors included social interaction, esthetic enjoyment, escape from pressures, and fishing itself. The highest rated single factor in fishing enjoyment was interaction with the family.

KEYWORDS: Esthetics, fishing, Utah, politics, benefits.

19. Anonymous
1908. Value of game. For. Q. 6(1): 104.

Income derived from hunting leases and amount of game meat sold are presented for Austria, Germany, France, Scotland, Switzerland, Prussia, and Hungary.

KEYWORDS: User fee, historical value, benefits, foreign country-general.

20. ________ 1910. Hunting in Prussia. For. Q. 8(4): 560.

The Prussian minister of agriculture briefly cites examples from Baden, Alsace-Lorraine, and Bavaria to show that renting the government forests for hunting to the highest bidders results in small income (Bavaria rents 1 million acres for little over 6 cents an acre) and much damage to the forest.

KEYWORDS: Germany, historical value, management, economics.

21. ________ 1911. Value of hunting in Germany. For. Q. 9(3): 511.

Brief data are given on money value of game killed in Prussia and on the cost per acre for hunting leases.

KEYWORDS: Germany, user fee, historical value, benefits.

22. ________ 1913. Game in Prussia. For. Q. 11: 284.

Foresters and landowners must be deprived of their ancient hunting privileges so that communal forests might be leased. By so doing, income from forests will increase, and the value of the trees as well as the game will be promoted.

KEYWORDS: Germany, management, historical value.

23. ________ 1920. Hunting in the State forests of the German States. J. For. 18(2): 175-179.

Management's object should be the insurance of greatest lasting returns to the State treasury, the protection of the silvicultural interests of the forest, and the prevention of injury to the general hunting business. Leasing is undesirable due to game stock or forest depletion.

KEYWORDS: Historical value, Germany, management.

24. ________ 1935. The conservation of wildlife. Am. For. 41(9): 482-487, illus.

A summary of historical conservation events, personalities, and legislation includes the following topics: wildlife and the pioneers, the market hunter, game laws, early game conservationists, organized game protection, wildlife administration, and migratory birds.

KEYWORDS: Historical value, conservation, waterfowl, upland game birds, administration, legislation.

25. ________ 1936. Wildlife management on private and State lands. Am. For. 42(3): 120-121, 147, illus.

Reviews are given on two papers concerning wildlife restoration. Aldo Leopold deals with the role of private land in wildlife management and concludes that the present program is lop-sided. The inherent characteristics of wildlife and land-use call for maintaining wildlife over large areas which would necessitate management of private lands. Elliott S. Barker discusses wildlife management by State agencies. Covered are jurisdictional questions, license fees, resource inventory, regulations, management plans, and restoration and maintenance of habitat.

KEYWORDS: Management, land owner-private, conservation, Federal-State jurisdiction, license fee.

26. ________ 1952. Voluntary sportsmen. Wis. Conserv. Bull. 17(2): 9-11.

In 1950, 204 purchasers of voluntary sportsmen's licenses were asked to indicate their occupations, comment on the Conservation Bulletin, and indicate interest response to a list of news stories and conservation projects.

KEYWORDS: Wisconsin, preferences, conservation, communications, characteristics.

27. ________ 1955. Is public hunting doomed? Part I. Field Stream 60(6): 40-41, 94-97, illus.

Public hunting opportunity is still good in the West due to open space, lower population, and much public-owned land. Although big game hunters are provided with many hunting opportunities, there are few public areas for waterfowl or upland game bird hunters. Each of the western game departments is attempting to induce farmers to open their lands to bird hunting. California promises strict supervision and law enforcement to farmers. Oregon posts "Hunting by Permission" signs and has also sponsored hunter's courtesy days and youth hunting preserves. Washington, too, has replaced "No Hunting" signs with "Hunting by Permission" signs and has turned poor-quality land into good hunting areas. In Utah, Hunter fees are used by the farmers for civic projects. Unfortunately, in both Utah and Colorado it is difficult to hunt unless one belongs to a private club since most marshland is in private club ownership. Nevada regulates hunter numbers on private land and extends protection to property owners. The Idaho Landholder Sportsman's Council serves as a planning conference between hunter, owner, and the game department. Public hunting has not died in the West because existing problems are being vigorously attacked. (Also see Part II (Titus and Laycock 1955) and Part III (Page and Camp 1955).)

KEYWORDS: Administration, landowner-private, waterfowl, upland game birds, farmer-sportsman relations, surveys.

28. ________ 1956. The impact of hunting and fishing. Tex. Game Fish. 14(9): 6.

A popular summary of National expenditures by type was taken from the 1955 U.S. Fish and Wildlife Service National Survey.

KEYWORDS: Fishing, economics, surveys.

29. ________

1957a. The boom in shooting preserves. Bus. Week Dec. 14,(1476): 164-165, 167-168, 170, illus.

The growth of shooting preserves stems from the increasing numbers of hunters and proportionately decreasing size of the hunter's bag. Commercial preserves are open to the public, and hunters are charged a fee for each bird they shoot. Clubs also manage preserves for the benefit of members. Memberships are offered for an annual fee. Shooting preserves are subject to several problems. The average operator makes only $5,000 a year on recovery of 5,000 birds. Recovery rate of released birds seldom exceeds 75 percent, and in some States bird take is restricted. While only 5 percent of the 1957 hunters used a shooting preserve, it is estimated that 50 percent of the Nation's hunters will use them regularly some day.

KEYWORDS: New York, upland game birds, waterfowl, commercial hunting, refuge, plant and shoot.

30. ________

1957b. Yellow good, red poor for hunters' clothing? Wis. Conserv. Bull. 22(3): 18.

An article from *Outdoor California* magazine is summarized, describing tests conducted at Washington's Fort Lewis to determine the safest protective color to wear while hunting. Results indicate a best rating for bright yellow and very poor rating for red. Eight percent of the male population is colorblind and cannot easily distinguish red.

KEYWORDS: Safety.

31. ________

1961. National survey of hunting and fishing. Tex. Game Fish. 19(10): 6-9, illus.

Popular presentation of results from the 1960 U.S. Fish and Wildlife Service National Survey is given. Also discussed is how Texas meets the demand of sportsmen.

KEYWORDS: Fishing, economics, characteristics, Texas, surveys.

32. ________

1969a. Game management notes. Fla. Wildl. 23(1): 30, illus.

On the average, it took hunters 29.1 days to kill a deer, 19.9 to bag one turkey, and 8.3 days to bag a wild hog. Quail hunters averaged slightly over three birds per day of hunting and 84,100 hunters averaged 8.4 man-days of quail hunting each.

KEYWORDS: Harvest statistics, Florida.

33. ________

1969b. Who has jurisdiction over wildlife? Idaho Wildl. Rev. 22(3): 14, illus.

KEYWORDS: Federal-State jurisdiction, legislation, management.

34. ________

1971. It's time to give the predators a break. Am. For. 77(11): 8-9.

Man is a predator, but we control his illegal activities by dealing with individual law violators, not by indicting the whole human race. Why not do the same with animal predators? Present predator control methods are dangerous to many species other than the ones specified for control. Large numbers of innocent animals are slaughtered for the sins of a few. The Missouri "extension trapper system" is discussed as a system which deals with the problem predator, not the entire species.

KEYWORDS: Predator, Missouri, management, trapping.

35. Armstrong, W. W.
 1958. The economic value of hunting and fishing in Arizona in 1956. Ariz. Fish Game Dep. Wildl. Bull. No. 4, 36 p, illus.

Descriptive study highlights the importance of hunting as an economic activity. Mail questionnaire survey yielded 61-percent return of 3,570 residents and 50-percent return of 675 nonresidents after two followup letters and a personal followup contact. Resident sportsmen spent $39,795,000 ($302 each) and nonresidents spent $3,300,000 ($161 each) on hunting and fishing in Arizona in 1956. These figures do not include $900,000 spent on licenses and permits. Fifty-five percent of the resident and 73 percent of the non-resident expenditures were for fishing. The $44 million expenditures approach those from several important industries in the State. Retail trade is probably the largest single industry in the State, but the amount spent for hunting and fishing in the State exceeds retail sales in nine of the State's 14 counties. Comparisons are also made with rental incomes, restaurant sales, and annual crop and livestock income. (Validity of findings may be in question due to high nonresponse. Questionnaire is included.)

KEYWORDS: Fishing, economics, Arizona.

36. Arrington, O. N.
 1948. Arizona's hunter reports. 28th Conf. West. Assoc. State Game Fish Comm. Proc. 28: 93-101.

The proceedings stress the importance of knowing the State's annual kill and hunting pressure, discuss four methods for gathering hunter report information (license stubs, checking stations, hunter canvass questionnaire, and hunter report cards), summarize and analyze deer report card returns for both 1946 and 1947, and tabulate deer, turkey, and elk permit-report card costs.

KEYWORDS: Arizona, research methods, harvest statistics, big game, upland game birds.

37. _________ and P. M. Cosper
 1953. The economic aspects of wildlife resources in Arizona. Ariz. Game Fish Comm. Fed. Aid Wildl. Restoration Div., 20 p, illus.

Mail questionnaire survey of 3,782 Arizona resident and non-resident hunters yielded 2,907 returns (76.9 percent) with two followups. The third return questionnaire was tabulated separately to estimate non-response bias, and this group's reported expenditures were less than those for early respondents. Tables and charts list the total expenditures and percent distribution on 13 items for six game species. Resident and non-resident expenditures are shown by species. Transportation, food-lodging, and rifles-shotguns constitute more than 50 percent of hunter expenditures.

High hunter spending in the State is influenced by the large number of game species, lengthy hunting seasons, a large percentage of residents that hunt, and the distance they must travel. Residents spend more than twice as much on firearms as nonresidents. Hunting expenditures in Washington and Colorado are contrasted, and the value of Arizona wildlife is compared with other Arizona incomes and expenditures. For example, life insurance premiums totaled over $19 million, while hunter expenditures were almost $6.5 million.

KEYWORDS: Arizona, economics.

38. Ashcroft, William H.
    1967. The socio-economics of recreational use of the Cache elk herd. M.S. thesis, Utah State Univ., 77 p., illus.

This is an excellent thesis pointing to changing preferences in wildlife use from consumptive to non-consumptive. Interviews are summarized of 530 out of 65,000 non-consumptive users who took a free sleigh ride through the Cache elk herd wintering grounds at Hardware Ranch, Utah. Elk were primary purpose of 98 percent of the visits. Visitors spent an average $1.22 per trip, and $80,000 for all visitors. Sleigh riders were willing to pay more before the ride than after, but present use could be maintained with a fee of $0.25. Based on willingness to pay, use would drop 62 percent with a fee of $0.75 to $1.00. Optimal fee was $0.50 with a 26-percent drop in use but a total revenue of $22,000 per year. Present facilities and sleigh rides are provided by game department from hunting license fees. Mail questionnaires to 517 elk permit holders yielded a 41-percent return. Results indicated over 30 percent made only one hunting trip to the area; but for every permit holder, two or three people came along. Fifty-six percent said they hunt elk for "both meat and pleasure but mostly meat." Figures over 33 years show an increase in the number of $15 permits and a steady decrease in hunter success. Hunters spent an average $14 on first hunting trip of the season. Recommendations include a $0.50 sleigh ride fee, improvement of facilities, and management primarily for sightseers.

KEYWORDS: Economics, preferences, harvest statistics, user fee, non-consumptive use, Utah, big game.

39. Atkeson, Thomas Z.
    1958. Shotgun versus rifles in gray squirrel hunting. J. Wildl. Manage. 22(1): 99-100.

Study involved seven managed hunts on Alabama's Wheeler National Wildlife Refuge. Data were gathered from checking station interviews and questionnaires with an enforced 80-percent return. Data reveal 3,881 persons using shotguns bagged 13,904 and crippled 2,108 (15.2 percent) gray squirrels. They spent about 19 cents per animal on ammunition, and 146 riflemen spent less than 6 cents, bagged 377 squirrels, and crippled 46 (12.2 percent). Riflemen hunted longer, fired more shots, took less game, spent less per squirrel, and crippled at a lower rate.

KEYWORDS: Harvest statistics, small game, Alabama.

40. Atwood, Earl L.
    1956. Validity of mail survey data on bagged waterfowl. J. Wildl. Manage. 20(1): 1-16, illus.

Knowledge of the pattern of occurrence and characteristics of response errors obtained during an investigation of the validity of post-season surveys of hunters was used to devise an effective two-step method for removing response-bias errors from survey data. Development of this method and its application to post-season hunter-take survey data increased the reliability of the data from below practical management significance up to the approximate reliability limits corresponding to the sampling errors.

KEYWORDS: Research methods, waterfowl.

41. _________ and Aelred D. Geis
1960. Problems associated with practices that increase the reported recoveries of waterfowl bands. J. Wildl. Manage. 24(3): 272-279.

Recovery of banded birds is around 50 percent. Special checking stations, publicity campaigns, rewards, and color-marking programs increase recovery but give inconsistent bias. Removal of incentive programs would increase reliability by stabilizing the ratio between reported and unreported birds.

KEYWORDS: Waterfowl, research methods, management.

42. Audubon Society
1972. The Audubon view. Audubon 74(1): 98.

This National Audubon Society policy statement regarding hunting states that the society has never been opposed to hunting of games species. They will advocate restrictions including closure of seasons if the welfare of a species warrants, but when the species recovers the society will again agree to increased take by hunters. The society's objective is wildlife and environment conservation--not the promotion of hunting. Therefore, the society does not advocate hunting; it just does not oppose it.

KEYWORDS: Administration.

B

43. Bade, August
1941. California's game management area law. Calif. Fish Game 27(3): 149-153, illus.

The 1939 game management area law provides a landowner (of at least 120 acres) with a game management area license which costs $10 per year and permits him to stock his area with quail or pheasant and to have a season set by the game commission. Correct procedures for license application, posting and banding, charging of fees, reporting on hunter statistics, sanitation, and law violations are discussed.

KEYWORDS: Management, landowner-private, California, user fee.

44. Bailey, James L.
1965. Enforcement problems relevant to juvenile law violations. 19th Conf. Southeast. Assoc. Game Fish Comm. Proc. 19: 457-464.

KEYWORDS: Enforcement.

45. Bandirola, Louis S.
1965. Economic values and conservation implications of fishing derbies. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 245-246.

KEYWORDS: Fishing, economics, conservation.

46. Barclay, John, and Karl E. Bednarik
1968. Private waterfowl shooting clubs in the Mississippi flyway. 33rd Conf. North Am. Wildl. Nat. Resour. Trans. 33: 130-142.

A questionnaire-interview study of 31 percent of approximately 3,941 private waterfowl clubs controlling over 1 million acres in 12 flyway States showed an estimated 5,000 waterfowling clubs control at least 2.5 million acres and habitat while Federal and State areas manage only 1.7 million acres. It was also concluded that 22 percent of the flyway's moderate to high value habitat is in private control, and club hunters do not secure a disproportionate share of the harvest although their effort is more productive. Thirty-eight percent of the man-days at private clubs are devoted to activities other than hunting. Clubs furnish opportunities for fishing, bird watching, and picnicking.

KEYWORDS: Harvest statistics, waterfowl, management, clubs, surveys.

47. Barclay, John Scribner
1965. Significant factors influencing the availability of privately owned rural land to the hunter. M.S. thesis., Pa. State Univ., 112 p., illus.

Mail questionnaires were sent to a sample of 1,463 owners of rural land 15 acres or larger in three Pennsylvania counties. Returns from 44 percent of the landowners provided the following information. Private land ownership accounts for 95, 82, and 65 percent of the total land areas of York, Huntington, and Sullivan Counties, respectively. Combined public and private land restricted against hunting is 47, 27, and 34 percent,

respectively. Factors affecting availability of private land are the owner's attitude and educational level, as well as trespass problems and posting. The owner's attitude is significantly influenced by his occupation type, hunting interest, and membership in State cooperative programs. Nearly 90 percent of those posting in each county were willing to grant permission to hunt on occasion.

KEYWORDS: Pennsylvania, access, farmer-sportsman relations, landowner-private.

48. Barker, Elliott S.
1941. Hunters and fishermen and the private property owner. 21st Conf. West. Assoc. State Game Fish Comm. Proc. 21: 33-38.

Farmer-sportsman relations are discussed based upon a questionnaire sent to western State administrators.

KEYWORDS: Farmer-sportsman relations, administration, surveys.

49. Barnes, Duncan
1962. The troubled hunter. Sports Illus. 17(8): 14-15, illus.

Inconsistency between government Fish and Wildlife Service duck population surveys and those made by Ducks Unlimited, a private organization, confuses the duck hunter.

KEYWORDS: Waterfowl, management.

50. ________
1966. Please don't feed the waterfowl. Sports Illus. 25(18): 32-39, illus.

The Migratory Bird Treaty Act makes it illegal to shoot ducks and geese over any area that has been deliberately baited, yet baiting continues despite the shortage of waterfowl.

KEYWORDS: Waterfowl, legislation, enforcement.

51. Barnes, Wm. B.
1946. The sportsman's questionnaire method of estimating the game kill in Indiana. 11th Conf. North Am. Wildl. Trans. 11: 339-348, illus.

A sportsman questionnaire was used as a convenient, inexpensive method for collecting kill statistics and other data pertinent to the success of the open season. Questionnaires were mailed to 15,121 randomly selected resident license holders and 1,630 free permittees. Only 6,116 were returned. Described are the purpose of surveys, other kill estimate methods, criteria, approach, followup, costs, and a formula for deducting non-use licenses. More importance is placed on average kill per hunting effort than on any other data.

KEYWORDS: Indiana, research methods, harvest statistics.

52. Bart, William M.
1972. A hierarchy among attitudes towards animals. J. Environ. Educ. 3(4): 4-6, illus.

Eighty-eight college students completed a "like-dislike" questionnaire for 30 North American animals. Responses were ranked by popularity,

and a tree theory analysis was performed to determine the hierarchy among the attitudes toward animals. Results show that the most popular animals were the horse, dog, and deer, while the least popular were the spider, snake, rat, and scorpion. A positive attitude toward rare and endangered species implied positive attitudes toward many other animals; however, a positive attitude toward a socially popular animal (horse) gave little or no indication of attitudes towards other animals. The rare and endangered animal received low popularity rankings. An example of the hierarchy model shows that liking a shark implies liking a pelican and a seal. Educators might utilize the hierarchy concept to formulate conservation education programs.

KEYWORDS: Preferences, non-consumptive use, big game, small game, education.

53. Bartley, Arthur
1961. Ducks Unlimited. Am. For. 67(4): 31, 64-66, illus.

Composition, explanation of policy, and history of the Ducks Unlimited conservation organization are presented.

KEYWORDS: Waterfowl, conservation, historical value.

54. Baumgartner, David Michael
1969. Forest resource use and management by large private hunting and fishing clubs in northern lower Michigan. Ph.D. diss., Mich. State Univ., 140 p.

Eighty-four hunting and fishing clubs 640 acres or larger were identified in northern lower Michigan. They control about 185,000 acres. Very few of the club forests, streams, or lakes have elaborate manmade recreational facilities. Hunting and fishing are the most popular activities. Large clubs control economic sources of raw materials to the region's pulp and paper industry, and over three-fourths have engaged in commercial cutting in the past 5 years. Forty-five percent of the large clubs are using management plans developed by foresters from the pulp and paper industry. The primary purpose of cutting is for wildlife habitat improvement rather than revenue. Although club archery and rifle deer hunters have over twice the average success of State hunters, it is doubtful that deer herds are under management control. The future of deer hunting and forestry practices are questioned unless professionals are more successful in showing club managers the need for deer herd control. Club managers are typically married, middle-aged, and highly educated professionals, business owners, or executives. (Condensed from Dissertation Abstracts.)

KEYWORDS: Fishing, Michigan, big game, landowner-private, management.

55. Baumgartner, F. M.
1942. An analysis of waterfowl hunting at Lake Carl Blackwell, Payne County, Oklahoma, for 1940. J. Wildl. Manage. 6(1): 83-91, illus.

Game kill records for 1940 indicate that hunters averaged 1.67 birds per day during 1,252 hunter days. Sunday overcrowding reduced average daily kill. Crippling losses show one duck was lost for every bird bagged. The controlled hunt was a success both economically and from the hunter's standpoint. Waterfowl species are listed by importance to hunters.

KEYWORDS: Waterfowl, economics, Oklahoma, management.

56. Baxter, John L., and Parke H. Young
1953. An evaluation of the marine sportfishing record system in California. Calif. Fish Game 39(3): 343-353, illus.

Data reveal that catch records have improved in quantity and quality. The records of total numbers of fish landed are said to appear accurate, and there has been some increase in the accuracy of individual species reports. The sport catch reports of important game fish are cited as being accurate enough to fulfill their intended purpose. Maintenance of the interest and support of sport boat personnel is of primary importance.

KEYWORDS: Fishing, research methods, California.

57. Beaufort, the Duke of
1948. The case for hunting. Natl. Rev. (Br.) 131(790): 585-590.

The President of the British Field Sports Society defends fox and stag hunting. This type of hunting has the hound killing the animal hunted and the gunless hunter riding horseback in pursuit. The main arguments against hunting are: it's cruel, it's the sport of the idle rich, it involves unnecessary expenditure and consumption of food for hounds and horses, and it causes crop damage. These points of contention are refuted and discussed as being false.

KEYWORDS: Antihunting, England.

58. Beebe, Frank L.
1971. The myth of the vanishing peregrine. North Surrey, Br. Columbia, Can., Can. Raptor Soc., 31 p.

This pamphlet purports to be a study in the manipulation of public and official attitudes. "The myth of the vanishing peregrine is a political wedge by which the high priests of the protectionist cause are attempting to obtain advisory control, with its implied legislative control of these birds, over most of Europe and all of North America," according to the author. The myth is perpetuated for the specific purpose of halting growth of falconry. The author attempts to show that publicly supported researchers have a conspiracy to get raptorial birds classified as "endangered species" because grants are available for the study of such species. "The peregrine does not belong entirely to nature," and, according to the author, "by right of history and tradition and by right of the intrinsic behavior of the species, this bird belongs to man. Falconers simply value these birds for their own personal enjoyment and wish to breed them in the context of enlightened self-interest." If falconers have to relinquish this historical right, they will go underground. Presented is a case history of the argument surrounding the myth of the vanishing peregrine from a falconer's viewpoint.

KEYWORDS: Falconry.

59. Belak, Edmund R., Jr.
1972. The outdoor magazines revisited. J. Environ. Educ. 4(1): 15-19.

This study is a content analysis of three major outdoor magazines--Field and Stream, Outdoor Life, and Sports Afield--for their development of environmental thought for randomly sampled issues in 1908, 1934, 1968, 1969, and 1970. Twenty keywords were used for tallying articles. In 1908 and 1934 these magazines carried articles mainly on wildlife problems, and

most of their environmental information was centered on fish and game. By 1970 these magazines contained almost a third more environmental information than they did in 1968, but little attention was given to air pollution and almost nothing on cultural problems. From 1968 through 1970 these magazines still centered environmental information around fish and game issues. The author concludes that outdoor magazines should place more emphasis on problems of air, water, and land quality and, if possible, cultural problems.

KEYWORDS: Communications, education, conservation.

60. Bell, James G.
1950. Public hunting grounds popular with city hunters. Wis. Conserv. Bull. 15(7): 20-21.

Origin of hunters using public hunting grounds in Wisconsin was discussed. One out of five came from Milwaukee and about 30 percent from the cities in the States of three regions of population concentration. (No information is given on sampling of the 16,884 hunters contacted and analysis of data is limited.)

KEYWORDS: Wisconsin, characteristics.

61. __________ Lloyd F. Gunther, and Laurence R. Jahn
1956. Horicon Marsh: the managed goose hunt - 1955. Wis. Conserv. Bull. 21(4): 23-25, illus.

Description of third annual managed hunt on Horicon Marsh presents hunter numbers, success, and conduct. Popularity of hunt led to problems of excessive use. (See Wiita and Bell 1959 and Bell, Jahn, and Gunther 1955.)

KEYWORDS: Wisconsin, waterfowl, harvest statistics, management.

62. __________ Laurence R. Jahn, and Lloyd Gunther
1955. Horicon's managed goose hunt - 1954. Wis. Conserv. Bull. 20(3): 12-14, illus.

Use figures, hunting pressure, success, and comments by hunters are discussed with area management problems based upon administrative records. (See Bell, Gunther, and Jahn 1956 and Wiita and Bell 1959.)

KEYWORDS: Waterfowl, Wisconsin, harvest statistics, management.

63. Bell, Thomas A.
1957. A study of the economic values of Wyoming's wildlife resources. M.S. thesis, Univ. Wyo., 140 p.

Mail questionnaires were sent to 3,263 resident and non-resident hunters and fishermen, 5-day tourist fishermen, and resident trappers to determine their economic impact on Wyoming. Eighty percent of the questionnaires were returned after three followup reminders. No less than \$23 million was spent for licenses, equipment, and other expenses. Resident sportsmen spent \$15 million while nonresidents spent \$8.3 million. Resident sportsmen spent 22 percent of their expenditure on transportation while nonresidents spent 38 percent on lodging and food. Both were the highest single expenditure in their category. Wyoming's wildlife resources compared favorably with the important agricultural industries of the State.

KEYWORDS: Wyoming, resident vs. nonresident, fishing, trapping, economics.

64. Bellrose, Frank C., Jr.
1947. Analysis of methods used in determining game kill. J. Wildl. Manage. 11(2): 105-119, illus.

Due to non-response bias, misinformation, and exaggeration of kill figures, it is suggested that check stations, interview surveys, or special calendars are more expedient methods for obtaining pertinent game kill statistics than are application reports, license reports, or questionnaires. Several game kill methods are evaluated with data on Illinois waterfowl kill.

KEYWORDS: Research methods, Illinois, waterfowl.

65. Benjamin, J. R.
1939. The Ohio Plan of State-supervised hunting on private lands. 4th Conf. North Am. Wildl. Trans. 4: 635-644, illus.

First year report is given on Ohio Division of Conservation program to supervise public hunting on private land to provide demonstrations of minimum cost of hunting, protection, education of landowners and hunters, and proper game management practices. Fifteen privately regulated demonstration areas ranging from 800 to 4,000 acres were approved for a 5-year program. The Division of Conservation was granted power to issue permits, post land, practice game management, and enforce laws without expense to owners. First year tables show for each area the total acreage, hunters registered, length of season, and the numbers of rabbits, pheasants, and partridges killed. Hunting pressure over season is graphically shown.

KEYWORDS: Landowner-private, harvest statistics, management.

66. Bennett, C. L., Jr., L. A. Ryel, and L. J. Hawn
1966. A history of Michigan deer hunting. Mich. Dep. Conserv. Res. Dev. Rep. No. 85, 66 p., illus.

This report brings together all available information about deer hunting in Michigan. Some of the tables date back to the late 1800's. A tabular history is given for the following topics: firearm and archery legislation and regulations, license sales and fees, areas closed to firearm and archery hunting, hunting season and bag limits, harvest statistics, hunter numbers, and hunting accidents. A few tables are broken down into resident and non-resident comparisons.

KEYWORDS: Big game, legislation, harvest statistics, archery, Michigan, resident vs. nonresident, historical value, accident, license fee.

67. Bennett, Logan J.
1949. Rural conservation education from the viewpoint of the Fish and Wildlife Service. 14th Conf. North Am. Wildl. Trans. 14: 200-203.

Four needs for rural conservation education are: greater appreciation by citizens of several hundred million migratory birds, greater appreciation of water conservation, greater awareness of the fact that on rangelands the evidence shows benefit to all including desirable livestock and humanity, and, last, that trout and bass are indicators of good farming.

KEYWORDS: Education, waterfowl, resource use.

68. Bennitt, Rudolf

1945. Some social factors influencing quail hunting in Missouri, 1938-1944. J. Wildl. Manage. 9(3): 195-202.

Data came from hunting reports on an average of 403 quail hunters each year for 7 years ending in 1944. Metropolitan hunters averaged fewer trips and fewer hours afield per season, fewer convoys flushed per day, fewer birds bagged per man-hour, and a higher proportion of crippled birds than rural resident hunters. They traveled farther afield and did a higher proportion of their hunting on the 12 "special days" of the season. The amount of quail hunting in Missouri was halved between 1939 and 1944, with relatively heavier hunting pressure on the 12 special days.

KEYWORDS: Missouri, upland game birds, characteristics.

69. ________

1946. University objectives in professional wildlife training. J. Wildl. Manage. 10(3): 218-227.

Comprehensive university training is needed and must extend beyond compartmentalized wildlife and biology courses to include general education and personal and social development. The role of colleges and universities should be to foster intellectual, social, and personal attainments that the term "profession" connotes. Because there will always be few jobs, quality not quantity should be stressed. Programs should screen upward and downward, i.e., identify potential leaders and failures.

KEYWORDS: Education.

70. Benson, Fred C.

1959. An analysis of Connecticut's free deer permit system. M.S. thesis, Univ. Conn., 74 p., illus.

Legislation resulting from over $20,000 in deer damage claims allowed landowners, members of families, and employees to kill crop-destructive deer at any time. Persons not owning or leasing property may hunt deer under a paid permit system. A landowner may endorse three such applications to hunt on property he controls. In 1956-57, deer were recorded killed on 491 separate properties by free permittees. Of this total, 431 interviews, mail questionnaires, and telephone contacts covered 87.8 percent of the property owners, 87.6 percent of the acreage involved, and 87.3 percent of the total free deer kill. In the 2 years, 214 (49.6 percent) of the properties were farms, 120 (27.8 percent) were semifarms, and 97 (22.5 percent) were nonfarms. Chi square tests indicated no significant difference in the types of property supporting deer killed. In the 2 years, 220 (51.0 percent) of the property owners reported deer damage, but only 13 owners reported damage beyond which they did not feel compensated by the year-round hunt. Such non-compensated damage estimates varied from $50 to $30,000 per property. Deer damage included browsing of laurel, "rubbing" of maple trees, and hay damage. Only 21.1 percent of the property owners issued paid permits and only 12.6 percent of the total available were issued. Only 32.2 percent of the persons given free deer permits used them. Of these, 68.4 percent killed deer but only 8.7 percent of the recorded deer were killed from March through September, the months when most crops would be most liable to deer damage. Landowners favored restricting paid permittees to shotguns only and preferred to eliminate small bore rifles. About 63 percent of the land owners approve of the archery seasons but did not mention "wounding of too many unrecovered deer" as the reason. Conclusion is that the majority of Connecticut property owners

regard animals as a recreational asset rather than as an agricultural liability. Extensive data allow evaluation of the deer damage problem and result of legislative attempt to cope with it. (Questionnaire-interview included. Literature cited, 4.)

KEYWORDS: Connecticut, preferences, archery, landowner-private, big game.

71. Berryman, Jack H.
1957. Our growing need: a place to produce and harvest wildlife. J. Wildl. Manage. 21(3): 319-323.

Development of a system of payment to the landowner is suggested to guarantee maintenance of habitat and adequate harvest opportunity.

KEYWORDS: Economics, philosophy, landowner-private, management.

72. ________
1958. Maintaining fishing and hunting opportunities--a constructive approach. 48th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 48: 66-72.

More people with more money, leisure, and mobility have placed increased demands on fishing and hunting stock. Suggestions to maintain fishing and hunting opportunities include an immediate study on social and economic aspects of management, a more efficient distribution of fishing and hunting pressure, an evaluation of existing resource legislation, application of zoning, and placement of fish and game management on an economic basis. Any reform coming from the above suggestions must be legally, economically, and administratively sound; it must also have the approval of landowners and sportsmen. A landowner compensation plan will pay the landowner for a continual supply of game. The sportsman, in paying, accepts his responsibility in conservation.

KEYWORDS: Landowner-private, management, fishing.

73. ________
1961. The responsibility of State agencies in managing hunting on private lands. 26th Conf. North Am. Wildl. Nat. Resour. Conf. Trans. 26: 285-297.

Question is debated of whether a responsibility to management exists. A seven-point program is suggested to set philosophy in action, which includes: intensifying management, improving relationships, improving coordination, reaching a broader public, considering the total environment, developing the economic potential of the wildlife resource, and reorienting education.

KEYWORDS: Landowner-private, administration, philosophy, education.

74. Bersing, Otis S.
1945. The hunter's report of the 1944 deer kill. Wis. Conserv. Bull. 10(10): 3-11, illus.

Deer tag returns yield information on harvest statistics, migration of hunters to Wisconsin counties, and percent success.

KEYWORDS: Harvest statistics, Wisconsin, big game.

75. ________
1950. Controlled hunting: what does it mean? Wis. Conserv. Bull. 15(12): 15-18.

Controlled hunting on a Wisconsin wildlife refuge regulates hunting pressure, prevents over-shooting, and insures wise harvesting.

KEYWORDS: Wisconsin, refuge, management.

76. ________
1966. A century of Wisconsin deer. Wis. Conserv. Dep., Game Manage. Div. Publ. 353-66. 2d ed., 272 p., illus.

This book presents historical data on deer hunting in Wisconsin from 1850 to 1964. Included are year, length and type of seasons, number of open counties, estimated gun kill, license sales, a chronology, deer population-location maps, deer tag sales, first closed counties, age and sex of kill, rank of counties having the highest gun kill, unit harvest per square mile of deer range, deer harvest by day, deer weights, and record deer. Similar data are given for bow and arrow deer hunting.

KEYWORDS: Wisconsin, big game, historical value, harvest statistics, archery.

77. Besadny, C. D., and Nick Calabresa
1967. Hunters welcome. Wis. Conserv. Bull. 32(5): 6-7, illus.

About 1,638 farmers open 235,000 acres to hunting under provisions of the Federal cropland adjustment program.

KEYWORDS: Farmer-sportsman relations, Wisconsin, access.

78. Bevins, Malcolm I., Robert S. Bond, Thomas J. Corcoran, Kenneth D. McIntosh, and Richard J. McNeil
1968. Characteristics of hunters and fishermen in six northeastern States. Univ. Vt. Agric. Exp. Stn. Northeast. Reg. Res. Publ. Bull. 656, 76 p., illus.

A mailed questionnaire posed 56 questions to 10,000 hunters and fishermen from Maine, Massachusetts, New York, Pennsylvania, Vermont, and West Virginia, yielding a 69-percent return. Report includes characteristics, patterns of participation in hunting or fishing, interest indices such as willingness to pay, sportsmen's magazines read, hours of participation, type of game pursued, and accessibility to opportunities. All age groups were represented. Sportsmen are slightly more educated than the general population. An average of 54 hours of vacation time was used for hunting and 41 hours for fishing. From 20 to 25 percent belong to sportsmen's clubs; 43 percent of the hunters and 38 percent of the fishermen were willing to pay for a day's outing. Over half have rural backgrounds; average income was just over $7,000 per year. The percent who hunted in 1965 for seven respective species or fished for eight respective species are given. Only 17 percent of the sportsmen had problems gaining access to land--mostly because of posting. (Research design and sampling are explained. Comparison of sportsmen characteristics is difficult, because general population characteristics are presented as medians while study findings are presented as means.)

KEYWORDS: Fishing, economics, preferences, research methods, characteristics, surveys.

79. Bianchi, Dennis H.
1969. The economic value of streams for fishing. Univ. Ky. Water Resour. Inst. Res. Bull. No. 25, 119 p., illus.

Stream fisheries should be economically valued and their loss deducted from the net benefits of a proposed reservoir. Using personal interviews the Kentucky Conservation Department contacted 3,172 stream fishermen. Economic value was determined by fitting data to a gravity-type model for predicting annual fishing use from the magnitude and distribution of surrounding population. Also utilized was unit value of a fisherman-day, which is estimated from the willingness to travel to find a suitable fishing site and estimated cost of that travel. Unit values were found to vary as functions of geographical location within Kentucky and stream size. The annual number of fisherman-days varied directly with stream size. The method seeks to determine the economic value of stream fishing under average Kentucky conditions. The method underestimates values associated with very desirable fishing sites and overestimates values of sites made undesirable by adverse natural conditions or disruptive human activity. No attempt was made to evaluate esthetic or other intangible stream qualities.

KEYWORDS: Kentucky, fishing, economics, resource use.

80. Biggs, John
1957. The question of reciprocal licenses. 47th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 47: 67-74.

KEYWORDS: Administration, fishing, license fee, resident vs. nonresident.

81. Biggs, John A.
1960. Wildlife and recreation on public lands--the next 50 years. 50th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 50: 97-106.

The history of the United States reveals that large areas were set aside to become National Forests, Parks, Monuments, and public land areas. Private lands were soon exploited to their utmost, and there followed an intensive, tragic exploitation of public lands for private use. This exploitation peaked in the early 1900's, and the right and interest of the public in these lands became paramount. In the years ahead, private exploitation will subside, public lands will become a valuable national resource, recreational and wildlife management uses will gradually dominate, and specialized types of recreational use will dwindle in favor of a multiple-use recreational philosophy. The total acreage of nationally-owned lands will not dwindle, and the harvesting of ever-increasing wildlife will become one of their greatest attractions.

KEYWORDS: Historical value, landowner-public, non-consumptive use.

82. Bird, Ronald
1963. Income potential of various kinds of farm recreational enterprises in Missouri. Univ. Mo. Agric. Exp. Stn. & Resour. Dev. Econ. Div., B783, 36 p., illus.

Many recreational enterprises adopted by Missouri farmers as a primary source of income were unsuccessful due to the operators' lack of experience in business, their inability to forecast the demand for their facilities, their use of word-of-mouth advertising only, and a lack of time and money spent to make the facilities attractive. Lack of credit was not a factor

that limited the expansion of the enterprises. The presence of public facilities benefited some but hindered others. The sale of deer hunting privileges and the rights to fish in farm ponds were ventures which did not justify their investments. Liability insurance premiums exceeded the gross returns in many cases. Successful operations were characterized by well located facilities and full-time, highly trained operators who had the ability to forecast facility demand.

KEYWORDS: Missouri, landowner-private, fishing, economics.

83. Blair, Frank D.
1951. The future of free hunting. Conserv. Volunteer 14(81): 1-8.

Free hunting can continue if soil and water are preserved and farmer-sportsman relationships improved.

KEYWORDS: Economics, farmer-sportsman relations.

84. Blaisdell, James P.
1964. A history of the conservation effort in Wyoming and the Wyoming Game and Fish Commission to 1950. M.A. thesis, Univ. Wyo., 138 p.

Early conservation efforts to 1920 are described in detail along with the events leading up to the formation of the Game and Fish Commission in Wyoming. The Commission's history is presented for the years 1937-50. (Extensive references.)

KEYWORDS: Wyoming, historical value, administration.

85. Bledsoe, Henry
1960. Advantages and disadvantages of nonresident hunters. 40th Conf. West. Assoc. State Game Fish Comm. Proc. 40: 87-90.

Non-resident hunters spent $10,381,629 in Colorado in 1959. Hunting license sales provide 63.7 percent of the revenue of the game department, and 46.7 percent of this comes from non-resident hunters. In 1959 resident hunters killed a total of 70,032 deer, while nonresidents took 37,088. Resident elk hunters took 8,553 animals, and nonresidents took 2,267. Although nonresidents are frequently accused of violating game laws, check station figures show that they are less likely to violate laws than are the residents. Unfortunately, resident hunters find that many landowners expect them to pay the same high fees for hunting privileges that the nonresidents are willing to pay. Nonresidents, however, spend more time in the field, have a higher success ratio than resident hunters, and help the State to obtain adequate deer harvests.

KEYWORDS: Resident vs. nonresident, user fee, Colorado, harvest statistics, economics, big game.

86. Boden, Wayne A.
1962. Wildlife recreation on industrial forest lands. M.S. thesis, Univ. Mich., 86 p.

Restricted to University of Michigan campus use.

KEYWORDS: Non-consumptive use, landowner-private.

87. Boles, Donald Edward
1956. Administrative rule making in Wisconsin conservation. Ph.D. diss., Univ. Wis., 335 p.

An administrative study describes public pressure leading to the creation in 1927 of a six-member conservation commission to improve administration and planning and to remove conservation from partisan politics. In 1933, the commission's powers were extended to fish and game. The primary sources of initiating conservation rules are department personnel, private groups, and the conservation congress or other advisory committees. The second major source involves public hearings. The most-utilized administrative review comes from direct submission of petitions. Personality plays an important role in rule formation due to the absence of formal standards in administrative review. The Wisconsin Supreme Court, recognizing this administrative process in conservation, has not interposed its attitudes in place of those of the administrators. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Wisconsin, legislation, conservation, historical value.

88. Bolle, Arnold W., and Richard D. Taber
1962. Economic aspects of wildlife abundance on private lands. 27th Conf. North Am. Wildl. Nat. Resour. Trans. 27: 255-267.

This unfinished survey focuses on wildlife productivity rather than consumption. Land in the United States is categorized as aquatic (high wildlife productivity, leasing for \$10-\$100 per acre per year), farm or agricultural (medium productivity, but rarely leases), and forest and range (low productivity, leasing for \$0.10-\$1.00 per acre per year). Farm lands show greatest potential for increasing hunting opportunity, but farms are becoming less of a family-household environment and more of an industrial business production unit. Improvement of landowner-sportsman relations rests upon improving the business function of farm land resources. Paid hunting on private lands, if made public policy, would provide incentive for perpetuation of wildlife habitat and abundance while providing income for farm-produced but State-controlled wildlife. (References cited, 11.)

KEYWORDS: Economics, user fee, landowner-private.

89. Bond, Robert S., and James C. Whittaker
1971. Hunter-fisherman characteristics: factors in wildlife management and policy decisions, p. 128-134. *In* Rec. symp. Proc., USDA Forest Serv. Northeast. For. Exp. Stn.

Results from a previous study of Northeast hunters are reviewed covering the learning experience, time for participation, utilization of and accessibility to the resource base, and type of fish and game harvested (see Bevins et al. 1968). Two motivational studies (More 1970, Spaulding 1970a) are reviewed, both illustrating the point that there is more to participation than killing game and catching fish. Game managers are urged to consider such factors in their decisions. Some opinions expressed by the authors are as follows. Future research efforts would be enhanced if managers better communicated their needs for information about hunters and fishermen. Knowledge of what is needed is necessary before collection of information. More in-depth motivational research is needed. Professional resource personnel can become social scientists and with backgrounds in both fields can contribute more than those with knowledge in only one discipline.

KEYWORDS: Research needs, benefits, characteristics, administration.

90. Bourjaily, Vance
1967. You can tell a hunter by what he hunts. Natl. Wildl. 5(6): 15-17.

The hunter is categorized and humorously characterized according to the type of game he pursues. He is the romantic esthete, the boisterous sportsman, the fastidious type, the table hunter, the American traditionalist, the big game hunter, the shooter, or the adventurer.

KEYWORDS: Characteristics.

91. Bowden, G., and P. H. Pearse
1968. Nonresident big game hunting and the guiding industry in British Columbia. Dep. Rec. Conserv., Fish Wildl. Branch, Br. Columbia Study Rep. No. 2, 69 p., illus.

Mail questionnaires were sent to 6,422 non-resident hunters to determine their hunting experience in the Province. After one followup mailing, 4,525 questionnaires or 74.6 percent were returned. Mail questionnaires were also sent to all 649 licensed guides in British Columbia, and 62.6 percent or 406 were returned. In 1966, 117,000 hunters hunted big game in British Columbia, of which 5.5 percent were nonresidents. During the last 5 years, non-resident hunters have increased 11.5 percent annually. Non-resident hunters tend to be meat hunters seeking moose, while residents consist mostly of trophy hunters. Non-resident hunters, mostly from the United States, spent $3.7 million in British Columbia in 1966, of which $2.2 million went for guide and packer fees. Nonresidents provide 93 percent of the clientele of the guide industry. In 1966, there were 1,237 guides, and 36 percent of them suffered financial losses. Local exclusive rights to commercially exploit game are often controlled by inefficient guides. Non-resident hunters object to a law requiring them to hire a guide.

KEYWORDS: Economics, resident vs. nonresident, guide, Canada.

92. Bowers, Robert R.
1960. The hunter's conflict. Am. For. 66(3): 15-16, 46-47.

An avid hunter becomes a farmer-landowner and changes attitude about hunter-landowner conflict. A farmer's primary consideration must be economic return. Desire to share game often conflicts with obligation to making a living from his land. Sportsmen are bargaining for privileges, not rights. They can become a farmer's asset not risk by paying for privileges to hunt or by offering a day's labor on the farm.

KEYWORDS: User fee, philosophy, economics, landowner-private.

93. Boyce, Arlow
1967. Farmland for you. Mich. Conserv. 36(5): 20-23, illus.

Michigan's cropland adjustment program provides free hunting privileges on 2,000 private farms throughout the State.

KEYWORDS: Farmer-sportsman relations, Michigan, access.

94. Braaten, Duane Ole
1970. Characteristics and angling desires of western Washington trout anglers, and a simulation of the fishery-management system so as to optimize angler enjoyment. Ph.D. diss., Univ. Wash., 155 p., illus.

This study of western Washington trout fishermen considered their characteristics and behavior and the values they placed on fish of different lengths and numbers. Data were gathered from a mail questionnaire sent to 6,000 licensed King County anglers. A logbook was used by 400 angling participants. Data indicated the following: no strong relationship between place of residence and distance traveled to lakes; 37 percent of the anglers fished on a lake more than 100 miles from home; the average fisherman was a 42-year-old married man with above-average income and education; and increased benefits to anglers could be obtained if the present 8- to 9-inch trout stocked in western Washington were reared to 11 inches, then released.

KEYWORDS: Fishing, benefits, characteristics, Washington, surveys.

95. Brander, Michael
1964. The hunting instinct, the development of field sports over the ages. 176 p., illus. Edinburgh and London: Oliver and Boyd Ltd.

Presented is an overall picture of the development of field sports such as hunting, hawking, shooting, and fishing. These are presented in relation to other historical events. For example, the development of hunting instinct during the 250 years following the Norman Conquest is presented along with the development of forest laws and the transition from the Dark Ages to the Middle Ages. Major literary works on the subject are critically surveyed in their appropriate historical places.

KEYWORDS: Literature, historical value, fishing, England, falconry, big game, small game, waterfowl, upland game bird, tradition.

96. ________
1968. A dictionary of sporting terms. 224 p., illus. London: Adam & Charles Black, Ltd.

Major sections of the dictionary include angling, falconry, game shooting, horsemastership, and hounds and hunting.

KEYWORDS: Dictionary, library, historical value, fishing, falconry.

97. Braun, Clait E.
1967. The future of public hunting. Colo. Outdoors 16(6): 13-14.

Rising land values, increased demand for hunting sites, plus a wide disparity between production costs and benefits of wildlife to the landowner, are resulting in a decrease of wildlife abundance and private lands for public hunting. Support by conservation agencies, State fish and game departments, and sportsmen of a small trespass fee to hunt on a private owner's land might alleviate the situation. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Economics, landowner-private, resource use.

98. Braun, Clait Evan
1965. A survey of the land values directly attributed to waterfowl within the contiguous United States. M.S. thesis, Mont. State Univ., 132 p., illus.

Of 588 duck and waterfowl clubs contacted by questionnaire, 59 percent responded. State game departments, Federal land assessors, personal observation, and interviews supplemented questionnaire data. About 11,000

waterfowl clubs control over 5.2 million acres in the Atlantic, Mississippi, Central, and Pacific flyways. Club members are assessed fees of at least $10 per year for membership. Land values attributed to waterfowl were related to type of fowl, hunting potential, dependability of flights, nearness to population centers, cropland vs. wetland, hunt regulations, potential harvest per acre, availability of free public lands, and alternative land uses. Hunting land values have increased no more than inflation since 1940 except goose hunting opportunities. Per-acre values range from a mean of $3.60 on the Mississippi flyway to $26.18 on the Pacific flyway with returns per acre greatest on cropland and least on wetland. Harvest statistics show, "As acres controlled per member increased, waterfowl harvest per acre decreased." Waterfowl club location, size, membership, and management of lands are discussed. Waterfowl populations, duck stamp sales, and harvest data are presented and their management implications discussed. (Over 160 citations but about one-third are personal communications.)

KEYWORDS: Harvest statistics, economics, management, refuge, surveys, waterfowl, clubs.

99. Breth, Harris
1948. Under the wildlife "blanket of ignorance"? 13th Conf. North Am. Wildl. Trans. 13: 176-181.

If wildlife makes "news," then the aim of wildlife management--to provide more game and fish for more sportsmen--will be fulfilled. A nationwide public relations program, based on the following, is outlined: dramatization of the deer story, asking national service organizations to set up permanent wildlife committees, holding quarterly State press conferences, thinking, talking and achieving "expansion" rather than "conservation," and setting up a clearinghouse of wildlife information to coordinate the program. Once America has the "facts" the problem is as good as solved.

KEYWORDS: Management, public relations, communication.

100. Brewer, Durward, and Glenn A. Gillespie
1969. Socioeconomic factors affecting participation in water-oriented outdoor recreation. U.S. Dep. Agric. Econ. Res. Serv. ERS-403.

Demand for water-oriented recreation can be estimated by assessing the socioeconomic characteristics of a given metropolitan population. In St. Louis, Mo., about 67 percent of 1,000 families interviewed said that recreation activities occupied one-sixth of all leisure reported. As family income increased, so did the amount of recreation. While boat fishing increased with increasing income, bank fishing remained approximately equal for all income groups. Fishing remained relatively constant for all education levels. The sex of the household head influenced family recreation activity. More children than adults participated in all activities except fishing and sightseeing. Boating, fishing, and hunting remained relatively constant as leisure time increased up to 60 hours, then declined rapidly. Almost 90 percent of the respondents were willing to pay a fee for use of facility. The mean entrance fees indicated for boat fishing, bank fishing, and hunting were $2.29, $1.38, and $2.17, respectively.

KEYWORDS: Fishing, Missouri, economics, characteristics, preferences, user fee, non-consumptive use.

101. Briggs, Philip T.
1965a. The sport fisheries for winter flounder in several bays of Long Island. N. Y. Fish Game J. 12(1): 48-70, illus.

The sport fishermen for winter flounder in several bays were studied from 1961 through 1963, and data were obtained from personal interviews with 35,824 anglers. An average of 193,482 anglers landed an average of 2,665,619 winter flounder each year. In all bays, the catch, the number of anglers, and catch per effort were highest in the spring. Fluctuations in the catch are discussed. Length-weight data reveal that winter flounder were in their poorest condition in the spring when fishing effort and the catch were greatest. Anticipated increase in fishing pressure for flounders would be best directed toward the fall fishery and season expansion in some particular bays.

KEYWORDS: New York, fishing, harvest statistics.

102. ________
1965b. The sport fishery in the surf on the south shore of Long Island from Jones Inlet to Shinnecock Inlet. N. Y. Fish Game J. 12(1): 31-47, illus.

The surf sport fishery between Jones Inlet and Shinnecock Inlet was studied by aerial census and by personal interviews with 8,457 day surf anglers and 2,401 night surf anglers. The number of anglers increased markedly from 1961-63. Night anglers generally had higher catches per effort for striped bass and bluefish than their daytime counterparts. Variations in abundance and fishing success for the other species are discussed. Better beach access is needed.

KEYWORDS: Fishing, harvest statistics, New York.

103. ________
1968. The sport fisheries for scup in the inshore waters of eastern Long Island. N. Y. Fish Game J. 15(2): 165-185, illus.

The sport fisheries for scup were studied between May 1 and Nov. 30, 1964-66. Data were obtained from personal interview of 18,078 daytime anglers, aerial observation, and from measurement taken on 4,824 scup. Together, anglers using rowboats and open boats accounted for two-thirds or more of all scup anglers. Rowboat anglers were most successful in May, while open boat anglers were most successful from midsummer to early fall. Differences between these and other sport fisheries for scup as well as seasonal fluctuations in scup abundance are discussed.

KEYWORDS: Fishing, harvest statistics, New York.

104. Bromley, A. W.
1945. Evaluation of the New York State experimental cooperative landowner-sportsman controlled public hunting grounds program, 1939-1943. 10th Conf. North Am. Wildl. Trans. 10: 9-29, illus.

The goal of the cooperative landowner-sportsman program was to solve the posted-land problem. It failed because only four or five of the 14 experimental areas realized consistently heavy hunting pressure, and cost per permit on most areas was prohibitive. The following must apply to future operation, or hunter complaint will outweigh good will: a reduction of unit permit cost, a daily hunter quota of 300, a success ratio of one

bird to three permittees, and artificial propagation of birds to meet the success ratio. The average cost per permit would be $1.25, given a total annual cost of $7,000 and a possible 5,600 permits issued per season.

KEYWORDS: New York, upland game birds, farmer-sportsman relations, economics, management, plant and shoot.

105. Brown, J. Hammond (Chairman)
1942. Problems of the sportsman. 7th Conf. North Am. Wildl. Trans. 7: 30-61.

Conference session entitled "Problems of the Sportsmen" included seven papers: "Problems of the Sportsman in Canada," by D. J. Taylor, "What the Sportsman Is Doing Through Ducks Unlimited," by E. S. Russenholt, "The Emergency Conservation Committee and the Sportsman," by C. N. Edge, "The State Game Administratory and the Sportsman," by Lithgow Osborne, "Pan-American Game Protection and the Sportsman," by T. Gilbert Pearson, "The Izaak Walton League and the Sportsman," by Kenneth A. Reid, and "Relations of the United States Fish and Wildlife Service to Sportsman," by Ira N. Gabrielson.

KEYWORDS: Canada, conservation, historical value, administration.

106. Brown, William G., Ajmer Singh, and Emery N. Castle
1965. Net economic value of the Oregon salmon-steelhead sport fishery. J. Wildl. Manage. 29(2): 266-279, illus.

Gross and new economic values are estimated from angler expenditure data obtained by mail survey during 1962. The net economic value is the annual value of the sport fishery resource to a single owner if a market existed for the opportunity of fishing for salmon and steelhead and it was measured from demand functions. Demand functions were based on income and distance traveled by the anglers. Net economic value was estimated to be about $3 million in 1962. If income and population trends of the past 10 years in Oregon continue, a 50-percent increase in net economic value by 1972 is predicted.

KEYWORDS: Research methods, Oregon, fishing, economics.

107. Brumsted, Harlan B.
1957. A workshop for sportsmen. 22d Conf. North Am. Wildl. Trans. 22: 607-619, illus.

Significant to this New York event was the fact that leaders among the State's sportsmen were interested not only in game and fish but also in basic limnology, flood control, and production forestry. The workshop has built an understanding between sportsman organizations and the Department of Conservation. Participants have, to an increasing degree, applied their workshop experience in solving local problems.

KEYWORDS: New York, resource use, education.

108. Buchheister, Carl W.
1963. The potential of State wildlife programs. 43d Conf. West. Assoc. State Game Fish Comm. Proc. 43: 46-51.

The National Audubon Society president recommends that game commissioners, who unhappily depend on revenues from hunting and fishing licenses and have only a narrow base of public support sustaining their programs, should broaden their programs to include a recognition of the recreational, esthetic, ecological, and scientific values of all wild things.

KEYWORDS: Administration, esthetics, non-consumptive use.

109. Buckingham, Nash
1937. The duck hunting racket. Am. For. 43(2): 52-55, 94-95, illus.

Federal Government failure to finance enforcement of the Migratory Bird Treaty Act has led to widespread abuse of its intent. Although the treaty states that "ducks shall not be sold" private duck clubs and shooting resorts flank migratory bird refuges with "strictly commercial" business operations. A court test case of the status of commercial duck shooting is needed to determine if such business is a violation of the spirit of the treaty which states "Ducks shall not be sold nor offered for sale in any manner."

KEYWORDS: Philosophy, enforcement, waterfowl, law violation.

110. Bucknall, Edmund J.
1967. Elk population control. Trail & Timberline. Colo Mt. Club. (Reprinted in Wild Cascades, Feb.-Mar. 1969, p. 18-19. North Cascades Conserv. Counc.)

Disagreement over methods in National Parks to equalize elk populations with the range-carrying capacity has led to hunting on adjacent park areas, transplanting, shooting by Park Rangers, and allowing natural starvation to occur. Reduction by Rangers is attacked by hunter's groups, but managers argue that hunting would instill a fear of man in park animals and reduce the possibility for visitors to see wildlife from the roads. No public hunt could approach the degree of control possible when carefully selected and equipped Rangers do the harvesting.

KEYWORDS: Big game, antihunting.

111. Bugg, J. S.
1967. Why an association of hunters? 47th Conf. West. Assoc. State Game Fish Comm. Proc. 47: 151-158.

The goals of the National Hunter's Association are outlined. They include: land acquisition, improved farmer-hunter relations, sportsman education, and cooperation with conservation organizations.

KEYWORDS: Farmer-sportsman relations, clubs, education.

112. Bullock, K. E.
1964. The joint venture of private and public management of our wildlife resources. 44th Conf. West. Assoc. Game Fish Comm. Proc. 44: 106-109.

To decrease problems with game management on private lands, the private landholders should be drawn into management programs. If they are not, the intensity of management will be much less than needed to produce the quantity of game for future needs.

KEYWORDS: Landowner-private, management.

113. Bunn, Lowell
1956. States favor either-sex deer hunts. Wis. Conserv. Bull. 21(12): 10-13.

Poll of 38 State game departments showed no opposition to either-sex hunts. Potential harvest, number of hunters, success ratio, total kill, and opinion of either-sex hunts are presented by State. Discussion promotes either-sex hunts.

KEYWORDS: Either-sex hunt, big game, surveys, harvest statistics.

114. Bureau of Economic and Business Research
1963. The economic value of fishing and hunting in Utah. Univ. Utah Bur. Econ. Bus. Res. Publ. No. 64-12, 19 p.

This publication is a second updating of a 1955 study. Each updating was made by adjusting money figures to account for inflation and increases in population. The author admits the weakness of this procedure but claims the figures are only educated "guestimates" or rough indicators. In 1955, sportsmen expenditures were $43.9 million, in 1959 the corresponding figure was estimated at $58.6 million or a 33.4 percent increase, and in 1963 the estimate was $69.9 million or a 19.2 percent increase over 1959 figures. Non-resident expenditures amounted to 9 percent of the total in 1959 and 1963, but license fees amounted to over 50 percent of the total fees collected. Resident expenditures are broken down into 14 categories, with equipment, transportation, and food leading the list. Non-resident expenditures are broken down into seven categories, with food, miscellaneous, and transportation leading the list.

KEYWORDS: Economics, Utah.

115. Burger, George V.
1962. Licensed shooting preserves in Wisconsin. Wis. Conserv. Dep. Tech. Bull. 24, 40 p., illus.

Wisconsin first licensed shooting preserves in 1931. Original regulations had been revised seven times by 1957 restricting size, number, and location of preserves. Present regulations allow a 75-percent harvest of planted birds and a 105-day shooting season. In 1957 only two of 72 licensed preserves operated commercially. Between 1935 and 1958, license cancellations about equaled new applications. In 1956, 37 preserves were used by about 700 hunters, or annually about 19 hunters per preserve. The Wisconsin shooting-preserve system has not resulted in financial gain, but most lands are in farm use. A major revision of regulations in 1959 removed the restriction against licensing areas including pheasant wintering grounds, eliminated extra credits for hens stocked in spring, lengthened the preserve hunting season, provided a minimum stocking requirement, and increased incentive for habitat management.

KEYWORDS: Refuge, management, Wisconsin, historical value, plant and shoot.

116. Burghardt, Gordon M., Ronald O. Hietala, and Michael R. Pelton
1970. Knowledge and attitudes concerning black bears by users of the Great Smoky Mountains National Park, p. 255-273. *In* Bears--their biology and management. Int. Conf. Conserv. Nature & Nat. Resour. Proc., Morges, Switzerland. New Ser. No. 23.

Questionnaire interviews on knowledge of bears, attitude, and demographic information were administered to 500 representative Park visitors. Analysis yielded data on visitor age, education, occupation, and residence. Most visitors knew that a young bear is called a cub but 10 percent knew the words "sow" and "boar," over two-thirds correctly recognized that the black bear eats primarily plant material, two-thirds knew that a bear can run faster than a human, over three-fourths said that bears would not make good lifelong pets, 47 percent correctly estimated the average life expectancy, and less than 10 percent knew the correct weights of bears. Data on characteristics of Park visitors in relation to knowledge of bears showed males with higher scores than females, and hunters scored better

than nonhunters. Sources of knowledge in order of importance were found to be park literature, road signs, books and magazines, personal experience, exhibits, television, other people, Park Naturalist talks, Park Rangers, and zoos or museums. Visitor attitudes showed that almost 90 percent wanted all native animals to be in the Park, aggressive behavior and proximity were given as the most troublesome bear behaviors, over half the visitors felt that troublesome bears should be removed to another area in the Park, "feeding bears" was the most often given reason for injuries by bears, two-thirds felt that present regulations were adequate, and finally when asked what they would do if they met a bear on a trail, 30 percent of the visitors said they would walk slowly away, 25 percent mentioned standing motionless, and 17 percent said they would run.

KEYWORDS: Big game, characteristics, non-consumptive use, preferences, education.

117. Burgin, Bryan E.
1959. Hunting accidents and hunter training - 1958. N. Y. State Conserv. 13(5): 30, illus.

New York hunting accidents are summarized for 1958: how inflicted, game hunted, and causes.

KEYWORDS: New York, accident.

118. ________
1962. Gun law for boys. Conservationist 17(2): 5, illus.

KEYWORDS: New York, education, safety, legislation.

119. Burks, Sterling Leon
1963. Utilization of Tishomingo Wildlife Management Unit by waterfowl and hunters. M.S. thesis, Okla. State Univ., 41 p., illus.

A portion of this thesis is concerned with the economic effect of an influx of hunters upon an Oklahoma community situated near the Tishomingo Wildlife Management Unit. Data were gathered from the records of businesses in Tishomingo and from personal interviews of hunters at check stations. Eight expense categories revealed that 1,607 hunters spent an average of $4.97 in Tishomingo and a total expenditure of $7,986. Hunters who bought decoys spent an average of $37 each for them. Geographical origin of hunters is included, along with total number of hunting trips, average hours hunted, and total waterfowl kill.

KEYWORDS: Economics, Oklahoma, waterfowl.

120. Burr, Alice S.
1952. Conservation laws and penalties. Fla. Wildl. 5(9): 18-19, illus.

Maximum wildlife violation penalties of the 1800's are contrasted with minimum current penalties in an appeal for adequate penalty laws by Florida'a legislature. For example, in 1895 a person violating the quail bag limit could be fined $25 to $50 or serve 60 days' hard labor for each bird in excess of limit. (No records of such convictions cited.) A random sample of 100 fishing violations from 1944-50 showed 29 violators were fined $10 or less, 19 were released, and 38 were required to purchase licenses and pay court fees.

KEYWORDS: Fishing, enforcement, historical value, law violation.

121. Burr, J. G.
1930. Does game increase when the landowner has a share in the game crop? 17th Conf. Am. Game Trans. 17: 25-33.

The history of the development of Texas' paid hunting system is given. The system has increased the game crop, as farmers find that game farming pays as well as, or better than, other crops. Landowners under the system are allowed to charge hunters $4 per day, or if the land is leased, 25 cents per acre for 1 year or less.

KEYWORDS: User fee, landowner-private, Texas.

122. Burress, Ralph M.
1961. Fishing pressure and success in areas of flooded standing timber in Bull Shoals reservoir, Missouri. 15th Conf. Southeast. Assoc. Game Fish. Comm. Proc. 15: 296-298.

In 1958, creel censuses on Bull Shoals reservoir yielded data on anglers who fished exclusively in three areas of flooded standing timber. The total acreage of the timbered area is 6.3 acres of a possible 2,380 acres. During 1959, nearly 15 percent of all anglers counted were timber fishermen. Fishing pressure in the timber was 5,138 hours per acre, as compared with 97 hours per acre in the rest of the census area. Fish harvest in the timbered area was 3,054 pounds per acre while the rest of the area averaged only 113 pounds per acre. In 29 months, 821 timber fishermen and 1,580 open water anglers were interviewed. Their rates of success and rates of catch were 94.8 percent and 1.25 fish per hour and 90.6 percent and 1.36 fish per hour, respectively.

KEYWORDS: Crowding, harvest statistics, fishing, Missouri.

123. Burroughs, R. D.
1939. An analysis of hunting records for the Prairie Farm Project, Saginaw County, Michigan, 1937. J. Wildl. Manage. 3(1): 19-25, illus.

Records from an 8,401-acre regulated pheasant hunting area show an average of 128 hunters spent about 3.7 hours per day hunting. Total cock pheasant kill was equivalent to 47 cocks per square mile. Dogs were used by 75 percent of the hunters, who bagged 87 percent of the pheasants.

KEYWORDS: Crowding, harvest statistics, Michigan.

124. _________ and Laurence Dayton
1941. Hunting records for the Prairie Farm, Saginaw County, Michigan, 1937-1939. J. Wildl. Manage. 5(2): 159-167, illus.

Hunting records kept on 8,400 acres during a 3-year period reveal hunting pressure in gun hours, cock pheasant kill, and kill per square mile. Sixty percent of the kill was made during the first week of the season and 80 percent by Monday of the second week. In 1939, 76 percent of the hunters were from four principle eastern Michigan cities.

KEYWORDS: Crowding, harvest statistics, Michigan.

125. Burrows, George Howard, II
1955. Model for a wildlife conservation field guide. PhD. diss., Cornell Univ., 419 p.

Demonstrated is the need for a popular wildlife conservation field guide for central eastern United States and Canada. A model guide should answer the following questions: (1) Any species threatened by extermination now? (2) Which are in danger? (3) What can the reader do to save them? (4) What is the management status of each species? and (5) Is the species increasing or decreasing? The guide should discuss the esthetic and recreational importance of each animal and present concise data on its habitat, productivity, and protection.

KEYWORDS: Conservation, Canada, non-consumptive use, communications.

126. Butler, A. J.
1930. Sport in classic times. 213 p., illus. London: Ernest Benn Ltd.

This historical classic cites a list of classical authorities and discusses the forms of sport hunting, fishing, and fowling. Included are articles on the advantages of hunting according to Homer, Orion, Plato, and others; the hunter and his equipment; a treatise on horse and hound hunting; large game (stag, boar, lion, bear, etc.); fishing and its techniques, including fly fishing; fowling in ancient times; and a discussion of other sports such as cock fighting and chariot racing.

KEYWORDS: Historical value, fishing, waterfowl, big game.

C

127. C., J. B.

1957. Canned duck calls on the pan. Am. For. 63(7): 8, 50, illus.

A mechanical high-fidelity recorder than lures ducks and geese within range of hunters' guns is the subject of much controversy. Opponents suspect that the device could lead to a massacre of the duck and geese population. The kill of geese in one Maryland county was estimated 50 percent higher than it was prior to hi-fi recorder use. The recorded sounds of contented geese feeding appear to be equally effective, in good weather or bad, and broadcast up to a quarter of a mile. A manufacturer defends his invention by stating, "It's no threat to the species providing wildlife officials enforce the bag limits." Increasing numbers of conservation groups and sportsmen have urged outlaw or regulation of these canned calling devices.

KEYWORDS: Waterfowl, conservation, Maryland.

128. Cahalane, Victor H.

1939. The evolution of predator control policy in the National Parks. J. Wildl. Manage. 3(3): 229-237.

A summary is given of 67 years of National Park predator policy which was affected by legal and natural limitations, public sentiment, and scientific inquiry. The rapid recovery of hooved mammals following near-extermination in the twentieth century was imperfectly perceived; and although predators became a necessity in the maintenance of a balance, persecution continued for at least a decade.

KEYWORDS: Predator, historical value, administration.

129. Cain, Stanley A.

1965. What is the place of fish and wildlife in outdoor recreation programs. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 4-9.

Water-skiing is used as an example to point out the pitfalls of predicting outdoor recreation trends. Skiers already interfere with fishing but provisions are made to accommodate both groups to minimize the conflict. Some conflict is inevitable and should be welcomed. It is better for an agency to have a variety of enemies than to be monolithic. Fish and game departments should stress the "quality experience" rather than the full creel or the size of the bag. Programs must benefit all types of outdoor recreation yet must preserve the grandeur of the continent as a heritage for future generations.

KEYWORDS: Administration, non-consumptive use, conservation, resource use.

130. Calhoun, A. J.

1950. California angling catch records from postal card surveys: 1936-1948; with an evaluation of postal card nonresponse. Calif. Fish Game 36(3): 177-234, illus.

The data provide annual estimates of total and average catch and numbers of anglers. Overall angling pressure increased fivefold from 1935 to 1948. Angling increased for each of the fishes surveyed, but average

annual catch declined for all but sunfish. A personal interview survey was conducted in 1948 to evaluate the influence of post-card nonresponse upon estimates. No bias of estimates of mean catches, numbers of anglers, total catches, or trout angler migrations was revealed, although nonresponse is an important source of error in California angling catch estimates.

KEYWORDS: Fishing, California, research methods.

131. Calkins, Frank J.
1963. Farmers' reactions toward upland bird hunting in two Utah counties, 1957. M.S. thesis, Utah State Univ., 63 p., illus.

Four hundred farm operators were interviewed, of which half were bird hunters themselves. Four percent of their land was closed to hunting, 44 percent was open, 31 percent was posted, and 21 percent was open with permission. Causes of land closure include protection of property, past damage or nuisances, private club control, and protection of pheasants. Seventeen percent of the farms suffered damage ranging from \$2.50 to \$213, but 65 percent reported rarely or never experiencing damage. Nuisances include open gates, shooting too close to buildings, hunting out of season, and hunting from roads. (Literature cited, 36.)

KEYWORDS: Utah, upland game birds, farmer-sportsman relations, landowner-private.

132. Campbell, Howard
1958. The economic value of hunting and fishing in New Mexico. N. M. Dep. Game Fish Bull. No. 7, 35 p., illus.

Mail questionnaires went to 3,225 resident and 692 non-resident sportsmen. Usable returns came from 60 percent of the residents and 62 percent of the nonresidents. Sportsmen spent an average \$231 yearly on their sport for a total by all sportsmen of \$31.8 million. Sportsmen spent more time fishing than hunting, both preferred trout over warm-water species, and deer and quail were the most popular game animals. The value of wildlife has high economic importance compared with agriculture and mining in the State.

KEYWORDS: Fishing, preferences, New Mexico, economics, resident vs. non-resident.

133. Cantwell, Robert
1965. A wretched mess of type, mostly about fishing. Sports Illus. 23(25): 71-74, illus.

Historical sketch is given of "The Wretched Mess News," a publication which began as a parody of other fishing periodicals and now combines wacky advice to the angler with attacks against conservation injustices.

KEYWORDS: Fishing, communications, Montana, literature.

134. Carey, Henry R.
1926. To whom does American wildlife belong? Am. For. & For. Life 32(394): 579-582, 620, illus.

The outdoors does not belong exclusively to the hunters and fishermen nor to any class. Conservationists and nature-lovers pay taxes and support the game laws, so wildlife management must consider them. Philosophical plea is made for broader conservation policies, especially for non-game animal species.

KEYWORDS: Management, philosophy, predator, non-consumptive use.

135. Carlson, Karen Andrea

1969. The Kenya Wildlife Conservation Campaign: a descriptive and critical study of inter-cultural persuasion. Ph.D. diss. Northwest. Univ., 368 p.

An analysis was made of the American and European unsuccessful attempts to introduce wildlife conservation to the population of Kenya. Wildlife was used as a fulcrum in which one culture attempted to make its values acceptable to another. The persuasion campaign was based on the American hypothesis that appreciation of wildlife is dependent on the audience's knowledge of a subject. The Africans did not accept conservation because educational materials were not similar to traditional persuasive devices, and cultural values about wildlife were not reinforced. Exposure to wildlife as esthetically valuable was not sufficient to change the attitude that wildlife was basically a source of food. Theory and practice of intercultural persuasion will be accurate only when careful analysis is made of interests, information, and cultural values of the audience. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Kenya, education, tradition.

136. Carroll, Theron

1957. Why kill does? Tex. Game Fish. 15(12): 10-13, 23-25, illus.

KEYWORDS: Big game, education, either-sex hunt, management.

137. Carter, W. D. "Pete"

1970. An experiment in promoting quality antelope hunting. 50th Conf. West. Assoc. State Game Fish. Comm. Trans. 50: 479-483.

A 3-year program to promote "quality" hunting showed that, of 66 antelope permits issued, 66 were successful, and 81 percent of the permittees shot a buck within first 2 days of season. Special regulations were imposed including a 2-1/2-hour prehunt indoctrination to acquaint hunters with life history, management practices, early hunting traditions, Boone and Crockett scoring, and skills of hunting. Many hunters were more impressed with hunting without competition than with abundance of game. Information was obtained from each hunter on number of buck antelope passed up before shooting, length of stalk, number of shots fired, number and location of hits, whether animal was as big as he had thought, whether the head would be mounted, and how he evaluated the hunt. (Significant implications about quality hunting are offered, but conclusions are based upon unreported data and opinions.)

KEYWORDS: Preferences, big game, education, harvest statistics.

138. Castle, Emery N., and William G. Brown

1964. The economic value of a recreational resource: a case study of the Oregon salmon-steelhead sport fishery. Conf. West. Agric. Econ. Res. Counc. Proc., Rep. No. 13, 12 p., illus.

This paper provides a critical examination and study of Oregon's salmon-steelhead sport fisheries undertaken to estimate the empirical demand function (economic values) of outdoor recreation resources. The study consisted of 3,700 mail questionnaires which had a 67-percent return. Demand was estimated by using transfer costs. These costs are those which are not normally included in prices, such as travel costs. Problems in assuming a monopolistic consumption occur, as well as determining competitive returns. (References cited, 16.)

KEYWORDS: Economics, fishing, Oregon, resource use.

139. Chalk, John D., D. I. Rasmussen, Frank C. Edminster, Colin McF. Reed, Arnold Nicholson, and J. Paul Miller
1940. Is the farmer-sportsman council the answer? 5th Conf. North Am. Wildl. Trans. 5: 54-82.

A discussion by five panel members includes the following topics: the history of game management in Utah and the appointment and progress of the State Game Refuge Committee and Board of Elk Control, the administration by farmers of a typical soil conservation district, local policy in Pennsylvania where farmers want protection and courtesy rather than pay, and encouragement of youth participation.

KEYWORDS: Historical value, farmer-sportsman relations, Utah, Pennsylvania.

140. Chalmers, Patrick
1936. The history of hunting. 384 p. Philadelphia: J.B. Lippincott Co.

This text gives a history of hunting from a classical medieval beginning to Victorian times. The English and Norman influences on hunting are presented.

KEYWORDS: Historical value.

141. Cheatum, E. L.
1953. The deer management problem in southern New York. N. Y. State Conserv. 8(1): 22-23, illus.

Three license management techniques to cope with increasing numbers of hunters are explored: (1) Continue present system with periodic hunter's choice seasons, an education program warning of degrading effect of hunter concentration, better safety program, and increased enforcement; (2) issue licenses on a quota system for antlerless deer; and (3) divide deer season into segments in which licenses are good for only part of the total season, thus spreading the hunting pressure.

KEYWORDS: Big game, New York, management.

142. Chesness, Robert A., and Maynard M. Nelson
1964. Illegal kill of hen pheasants in Minnesota. J. Wildl. Manage. 28(2): 249-253.

Hunter interviews are compared with postseason X-rays of dead birds as a method for determining hen kill. Interviews with 1,157 hunters indicated an illegal hen kill of 3 to 6 percent compared with 11 percent for X-rays. Biases in the X-ray technique seem compensating, thus suggesting greater accuracy than hunter interviews, which tend to underestimate illegal hen kill. Study results compared closely with other studies. (References, 8.)

KEYWORDS: Minnesota, research methods, upland game birds, law violation.

143. Child, George W.
1971. Angler motivation in fishing site selection. M.S. thesis, Univ. Mass., 85 p., illus.

Study objectives were to determine sport fishing motivation, to explain distribution of fishing effort, to analyze characteristics of fishing sites within a 20-mile area in Massachusetts, and to predict the success of fresh-water sport fishing. A 53-percent mail questionnaire sample was taken of all license holders within the 20-mile area. Results are based upon less than a 25-percent return rate. Regression analysis and multiple discriminant

analysis used in analyzing data failed to produce empirical conclusions. (References, 40.)

KEYWORDS: Massachusetts, fishing, preferences.

144. Childs, Leslie
1932. The rights of sportsmen to use public lakes and streams. Am. For. 38(8): 459.

KEYWORDS: Landowner-private, legislation, historical value, access.

145. Christiansen, John R., William S. Folkman, J. Loraine Adams, and Pamela Hawkes
1969. Forest fire prevention knowledge and attitudes of residents of Utah County, Utah, with comparisons to Butte County, California. Brigham Young Univ. & Pac. Southwest For. & Range Exp. Stn. Soc. Sci. Res. Bull. No. 5, 26 p., illus.

Comparative interview study is between 901 respondents of Utah County and 761 of Butte County. Nearly eight of 10 of the Utah County residents had visited a National Forest once during the year preceding the study. Frequency of visits was related to age, sex, marital status, education, occupation, income, and residence. Knowledge about fire prevention was higher among the Utah population than among the comparable Californians. Frequent forest visitors, especially hunters and fishermen, scored better than average on the knowledge test. The mean percentage scored by Utah County residents was 81 while the mean score of hunters and fishermen was 96. Participation rate in fishing and hunting in Utah County ranked below sightseeing and picnicking but ahead of camping and hiking. Fire was used in connection with fishing 36 percent of the time and with hunting 53 percent of the time. Most respondents felt forest fires were a threat to public forest property, but few felt their personal property was threatened. Responsible attitudes were characteristic of older, urban-dwelling, fire-experienced, authority-tolerant, and fire-knowledgeable persons. Of the respondents, 58 percent indicated they had heard or read about forest fires in Utah from newspapers, radio, or TV. Fire prevention programs should be geared to ill-informed but active forest users. (See Folkman 1963 and 1965.)

KEYWORDS: Fire, characteristics, California, Utah, education.

146. Christiansen, Rudolph A., Sydney D. Staniforth, Aaron Johnson, Jr., and Rollin B. Cooper
1969a. Economic aspects of privately owned fishing enterprises in Wisconsin. Univ. Wis. Coll. Agric. Life Sci. Rep. No. 46, 13 p., illus.

A sample of 58 of Wisconsin's 1,516 private fishing enterprises was surveyed. Boat rental and fishing pond enterprises geared to trout averaged 8.3 and 6.5 acres, respectively. Almost 50 percent of the operators had other full-time jobs. The boat rental enterprises had an average capital investment of \$19,113. The average return to family labor and management for 45 enterprises was \$2,183. Operators mentioned "getting along with the public" and "knowing the business" as important management factors and ranked high taxes as their most important problem.

KEYWORDS: Economics, fishing, Wisconsin, landowner-private.

147. _________, Sydney D. Staniforth, Aaron Johnson, Jr., and Rollin Cooper
1969b. An economic survey of privately owned shooting preserves in Wisconsin. Univ. Wis. Coll. Agric. Life Sci. Res. Rep. 47, 11 p., illus.

The 22 licensed preserves surveyed were primarily stocked with 8- to 12-week-old pheasants costing $1.50 per bird and hunted for about $5.25 each by hunters. The average investment per shooting preserve was $20,063 with a range from $5,100 to $75,000. Average acreage was 267, and land values were about 85 percent of the total investment. In 1965 gross recreation income averaged $7,056 per enterprise. Annual operating costs were 60 percent of gross income, most of this going for pheasant purchases. The return to family labor and management averaged $1,637 after deducting depreciation and use of capital from net income. It was concluded that shooting preserves concentrate around large population centers and are part-time, highly seasonal recreation enterprises. Advertising and public relations upgrading is needed if the volume of business is to increase.

KEYWORDS: Landowner-private, plant and shoot, Wisconsin, upland game birds, economics, refuge.

148. Churchill, Warren
1957. Conclusions from a ten-year creel census on a lake with no angling restrictions. J. Wildl. Manage. 21(2): 182-188, illus.

Escanaba Lake in Wisconsin has been under experimental management since 1946 with no restrictions on hook and line fishing for any species. Complete harvest records were kept and other information was collected by a compulsory permit system. In 10 years, 97,387 fish weighing 49,414 pounds were harvested. Perch and walleye made up 80 percent of the catch. Fishing success varied from 0.17 to 1.1 fish per hour. Fishing restrictions in effect elsewhere would have reduced the 10-year catch of game fish by more than 50 percent. There was no evidence of depletion after 10 years of unrestricted fishing.

KEYWORDS: Fishing, harvest statistics, Wisconsin, management.

149. _________ and Howard Snow
1964. Characteristics of the sport fishery in some northern Wisconsin lakes. Wis. Conserv. Dep. Tech. Bull. No. 32, 33 p., illus.

Data on the fisheries of two research projects which were obtained by a creel census using compulsory fishing permits include the following: from 1957-61, 55,127 fishing trips were made; for 1958-61, 64 percent of all anglers were men, 16 percent women, and 20 percent children under 16. Two-thirds of the Five Lakes anglers and four-fifths of the Murphy Flowage anglers were from Wisconsin. Over half the angling trips were made in summer, 26 percent in spring, 5 percent in fall, and 14 percent in winter. At Murphy Flowage, boat fishermen averaged 4.2 hours per trip and bank fishermen averaged 2.4 hours. Average catch for all anglers was 6.7 fish per trip. A great variety of methods and baits was used by the anglers. The highest rate of catch of both game fish and panfish occurs in the winter. Conclusions are drawn for guiding anglers, managers, and planners.

KEYWORDS: Wisconsin, fishing, harvest statistics, characteristics.

150. Cicchetti, Charles J., Joseph J. Seneca, and Paul Davidson
1969. The demand and supply of outdoor recreation, an economic analysis, 301 p., illus. Rutgers Univ. Bur. Econ. Res.

A national analysis was made of supply and demand relationships in outdoor recreation participation. Objective was to develop a theoretical supply-demand system model for simulation and prediction of participation

in specific outdoor recreation activities (including hunting). National recreation use in 1965 showed 310.7 million recreation days with a projected increase to 408.4 million by 1980 and 449.6 million by 2000. Hunting showed 131.8 million recreation days in 1965, is expected to increase to 135.5 million days by 1980, but decrease to 107.3 million days by 2000. Crowding and/or population density are credited for the decline in hunting after 1980. Other recreation activities are included. (Competent detailed analysis of national recreation participation data is perhaps the best to date.)

KEYWORDS: Economics, fishing, landowner-private.

151. Clark, John R.
1962. Salt-water angling and the resources problem. 27th Conf. North Am. Wildl. Nat. Resour. Trans. 27: 347-350.

A survey conducted by the Bureau of Census canvassed 45,000 persons in 18,000 households for information on the salt-water fishery and its role in the national recreation picture. Survey data indicate that 6,198,000 salt-water anglers took 632,872,000 fish in 1960, a heavier drain on the resource than expected. Present predictions call for a near fivefold increase in salt-water anglers by the end of the century.

KEYWORDS: Crowding, fishing, research methods, resource use, surveys.

152. Clarke, C. H. D.
1958. Autumn thoughts of a hunter. J. Wildl. Manage. 22(4): 420-427.

Many emotional arguments are advanced against hunting, but the main question is this: Is it right or good for man to inflict death or pain on a wild animal? Albert Schweitzer expresses reverence and awe for life and affirms that civilization is decaying. This idea is similar to Aldo Leopold's "ecological conscience" of conservation ethics which is closer to the heart of the problem of civilization, but the biologist views killing animals as harmful only if the whole organic complex is upset. Hunting also has been examined in terms of "play"--something beyond simple physical need. Hunting satisfaction is partly esthetic but also deeply rooted in the maintenance of an old and harmonious relationship with nature. The hunter cannot be blamed for death so long as his conscience, ruled by his respect for nature, governs his actions. Cruelty, or the willful infliction of pain, plays no part in the purpose of hunting. The goal of shooting is a clean kill. Hunting remains, as it was in the beginning, completely assimilated to the basic processes of organic nature, in which death and life spring from each other.

KEYWORDS: Antihunting, philosophy.

153. ________
1960. Fishing and hunting in relation to recreational planning in the Canadian provinces. 50th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 50: 117-121.

KEYWORDS: Administration, Canada, resource use.

154. Clawson, Marion
1958. Statistics on outdoor recreation. 165 p., illus. Resour. Future, Inc., Wash., D. C.

Book contains valuable trend data and commentary on hunting and fishing statistics. Chapter on "Hunting and Fishing as a Type of Outdoor Recreation"

(p. 93-106) summarizes national figures based on hunting and fishing license sales and on the survey of fishing and hunting (see U.S. Bureau of Sport Fisheries and Wildlife 1955). Tables, graphs, and maps present national and State breakdown of license purchases and costs and age distribution of sportsmen, broken down by resident and non-resident sportsmen. Trend data are also presented for 1923-56. Appendix tables 18 through 24 present information in more detail.

KEYWORDS: Economics, fishing, resident vs. nonresident, non-consumptive use.

155. Clement, Roland C.
1969. Instincts, laws, and ducks. 34th Conf. North Am. Wildl. Nat. Resour. Trans. 34: 346-352.

Opposing views on human aggression are discussed. Is aggression the source of all progress and merely in need of constructive outlets, or is it a social maladjustment at the root of violence? Hunting has yet to be studied from the viewpoints of psychology or ethology. Most comments on hunting are casual, speculative, or made to bolster another point of view. Whether or not hunting is an instinct, hunters should not be expected to behave ethically if they are encouraged to seek satisfaction afield and are then frustrated by circumstances the lawmaker well knew could not lead to satisfaction. Federal wildlife agencies should discontinue the promotion of hunting and stick to environmental conservation, according to this National Audubon Society member.

KEYWORDS: Antihunting, management, philosophy.

156. Coleman, Earl P.
1968. The Miranda and Escobedo decisions and their effect on wildlife law enforcement. 22d Conf. Southeast. Assoc. Game Fish Comm. Proc. 22: 524-527.

KEYWORDS: Enforcement, education, administration, legislation.

157. Conger, Dane H.
1962. Hunting and fishing in National Parks. 52d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 52: 24-29.

Hunter harvest of surplus park animals in cooperation with or under the supervision of the State involved is favored.

KEYWORDS: Resource use, big game, administration, refuge.

158. Conway, Ralph C.
1943. Proposed public shooting grounds program. Wis. Conserv. Bull. 8(11): 3-9.

Early legislation, history, and management practices of Wisconsin's public hunting and fishing grounds are reviewed with suggestions for the acquisition of new areas, the schooling of new personnel, and the management of damage claims and settlements.

KEYWORDS: Administration, landowner-private, refuge, historical value, economics, Wisconsin.

159. Conway, William G.
1966. Why have zoos? Parks Rec. 1(6): 488-490, illus.

KEYWORDS: Urban wildlife, non-consumptive use.

160. ________
1969. The consumption of wildlife by man. Parks Rec. 4(2): 21-26, 46-50, illus.

The loss of many specimens of rare wildlife through the pet trade's uninformed personnel and lack of regulations is discussed. Medical research, zoo demands, the skin trade, sport and food hunting, and the changing environment also threaten many. More than 28 million animals are imported yearly for zoos, laboratories, and pets. Many statistics are presented.

KEYWORDS: Urban wildlife, non-consumptive use.

161. Cook, Robert C.
1952. Health-wealth-future security. 17th Conf. North Am. Wildl. Trans. 17: 81-87.

This comment was made after the formation of a statement of policy of the newly formed National Resources Council. Author makes strong recommendation that the objective of the council should be an ecological approach to the conservation program which accounts for social, geographical, and biological phenomena.

KEYWORDS: Conservation, resource use.

162. Cooke, R. J.
1965. Program for improved fishing and hunting. Rod Gun 66(8): 20-21, illus.

The Canadian Industries Limited Wildlife Management Fellowship plan which was introduced to provide Canada with trained scientists to further conservation is discussed.

KEYWORDS: Administration, Canada, education, conservation.

163. Cooper, James A.
1969. An evaluation of species identification levels for a sample of Massachusetts waterfowl hunters. M.S. thesis, Univ. Mass, 57 p., illus.

Effective species management requires hunters capable of identifying species. A questionnaire employing profiles of 37 species of waterfowl and closely related birds tested the ability of hunters to identify waterfowl species. Data were collected by mail survey and personal interview. The response rate was 62 percent for the questionnaires and 41 percent for the interviews attempted. An average 42 percent of the birds were identified correctly in the mail survey, but only 29 percent in the personal interview survey. Only four birds (the Canada goose, the drake mallard, drake wood duck, and the drake pintain) were known well enough by the hunters to be selectively harvested. Most hunters tested could not distinguish the female mallard from the black duck. The waterfowl hunter with the highest ability to identify waterfowl may be characterized as a hunter who started hunting at an early age, hunts frequently, participates in sportsman club activities and in the special black duck season, and reads a sportsman's magazine. He also bags most of the waterfowl, hunts on the coast, and is willing to take a waterfowl knowledge examination if this becomes necessary to obtain a duck stamp.

KEYWORDS: Management, waterfowl, research methods, Massachusetts, characteristics.

164. Copelin, Farrell F., Earl Craven, Charles O. Gilliam, and Jim Adcock
1964. Waterfowl hunting activities and harvest in the Tishomingo National Wildlife Refuge, Oklahoma, 1960-1963. 18th Conf. Southeast. Assoc. Game Fish Comm. Proc. 18: 79-90, illus.

KEYWORDS: Management, waterfowl, refuge, Oklahoma.

165. Cornwell, George W.
1967. The potential contributions of wildlife extension education. 32d Conf. North Am. Wildl. Nat. Resour. Trans. 32: 211-227.

This excellent conceptual description of wildlife extension education includes: an historical review, an examination of the functions of an idealized State program, a discussion of the nature and caliber of Federal leadership in wildlife extension, and recommendations for future expansion of national and State wildlife extension efforts.

KEYWORDS: Education, administration, research needs, historical value, communications.

166. Cosper, P. M.
1958. Selling hunting season recommendations. 38th Conf. West. Assoc. State Game Fish Comm. Proc. 38: 197-199.

KEYWORDS: Administration, public relations, Arizona.

167. Cottam, Clarence
1947. Some improvements needed in wildlife research. J. Wildl. Manage. 11(4): 339-347.

Improvements for wildlife conservation research include emphasis on urgent management problems, development of a scale of relative values in determining priority of research assignments, better administration and supervision, clear justification of researcher modifications, development of a simplified cost-accounting system, current analysis and clearer publication of data, credit given where due, and finally, a better appreciation of the importance of research as a foundation for practical info - mation and management.

KEYWORDS: Research needs, profession, administration.

168. ________
1950. The *why* of migratory waterfowl regulations. 40th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 40: 119-129.

Also see condensed version, same author and title, in *Texas Game and Fisheries* 9(1): 4-7, 31, illus.

KEYWORDS: Waterfowl, management, conservation.

169. Couture, Lawrence H.
1953. A study of the economic, esthetic and recreational values of the wildlife resources of Massachusetts. M.S. thesis, U. Mass., 93 p., illus.

Mail questionnaires were sent to 2,000 (0.6 percent) of the State's 314,536 resident license buyers. A raffle drawing of $10 was made to prompt questionnaire returns. Total response was 52.7 percent after one followup letter. Expenditures were also tabulated for 203 nonrespondents

who were interviewed personally. Hunters and fishermen contribute over \$55.9 million to Massachusetts yearly for sporting goods. The sale of resident licenses during 1951 totaled \$610,535 and the value of the costal sport fishery is estimated at \$18 million. Proportionally, the greatest sum of money was spent directly or indirectly for fishing. Sportsmen most preferred deer and rabbit hunting. Trout were the preferred game fish on more than 51 percent of all fishing trips. Almost 71 percent of the trips made to coastal areas were for striped bass exclusively.

KEYWORDS: Fishing, Massachusetts, economics, non-consumptive use, preferences, characteristics, benefits.

170. Coyner, James G.
1961. Enforcement of wildlife laws along State lines. 41st Conf. West. Assoc. State Game Fish Comm. Proc. 41: 245-249.

KEYWORDS: Enforcement, legislation, historical value, law violation, administration.

171. Crawford, Bill T.
1951. The field bag-check method of determining hunting success, pressure and game kill. 16th Conf. North Am. Wildl. Trans. 16: 307-315.

Because compulsory license tab reports, data collections by licensing agents, questionnaires, and personal interviews after the season are often unreliable, Missouri instituted a method of hunter inventory in the field. Processing and systematizing of these reports yield data on a statewide and a regional basis. The bag check system also yields figures on participation by the unlicensed rural hunter. The main application is in heavily pressured small game and waterfowl areas where cost of collecting hunting statistics by this system is negligible.

KEYWORDS: Research methods, Missouri, harvest statistics.

172. Crawford, Glenn Henderson
1941. Improving Louisiana's inland fishing through promotional means. M.S. thesis, La. State Univ., 119 p.

A variety of social and environmental factors have decreased Louisiana's fresh water fish supply since 1902. Public opinion should be used in improving this condition. Different questionnaires were sent to 64 parish sheriffs, 25 city organizers, 11 radio stations, 25 sporting goods dealers, and 15 newspapers. Of the 140 questionnaires sent, only 50 percent were returned. Results showed that public interest in fishing is greater than 10 years previous because of better transportation and roads, more leisure, better equipment, advertising, more areas accessible, etc. Suggestions are presented for integrating conservation in the public school classes such as English, civics, history, home economics, science, agriculture, physical education, and industrial arts. Presented also are a brief history of conservation of fresh water fish in Louisiana and possibilities for fresh water fishing. Author recommends closed season during spawning, \$5 non-resident license fee, lowering bag limit to 50 fish per day, more artificial lakes, and elimination of pollution.

KEYWORDS: Fishing, Louisiana, public relations, education, historical value.

173. Creed, William A.
1963. Make mine BIG! Wis. Conserv. Bull. 28(5): 8, illus.

Article proposed "trophy hunting" as hunting's most satisfying goal with interesting data on probabilities of such kills. Few "hunters would exchange a crack at a real trophy for a lesser deer!" Few bucks under 3½ years old are trophies, according to author. But, in Wisconsin, two tallies showed that only two out of 10 and 11 of 100 bucks harvested had reached 3½ years, while four and two out of 1,000 were 6 years old. Raising bucks to trophy size presents difficult management problems, although it is done in central Europe for a few hunters at a high price. Hunting in large roadless areas and where hunters are few is suggested for locating a trophy.

KEYWORDS: Preferences.

174. Crinigan, Richard P., Jr.
1962. Hunter's vision screening tests. Conservationist 16: 29.

Nine hunter screening tests are described, including color vision, depth perception, and convergence tests.

KEYWORDS: Safety, accident.

175. Croft, Robert L.
1963. A survey of Georgia bow hunters. 17th Conf. Southeast. Assoc. Game Fish Comm. Proc. 17: 155-163.

A mail survey of archery hunters during the 1962-63 hunting season yielded 95-percent returns giving a sample of 458 archers. Results show that 94 percent of these hunters hunted more than one species. An estimated 578 bow hunters spent 2,839 days to take 141 deer with an average hunting success of 24.5 percent. There were 111 deer hit where sportsmen did not recover the game. Hunting success increased with hunting experience. (Questionnaire is included.)

KEYWORDS: Big game, archery, Georgia.

176. Crutchfield, James
1964. Fish and wildlife values in relation to other resources. 44th Conf. West. Assoc. State Game Fish Comm. Proc. 44: 48-56.

Water and land utilization projects are subject to sophisticated techniques of evaluation, and the same techniques should be used with fish and wildlife in order to compete with other resources. Free hunting and fishing resulted from a resource overabundance that is now depleted. User fees would provide the real value people place on recreation. Studies using cost of overcoming distance as a measure of willingness to pay are expensive, technically difficult, and soon outdated. This technique is conceptually correct and estimated a market better than "phony techniques" such as the gross expenditure on equipment, facilities, and services, or the "What are you willing to pay?" technique. The true conservationist has everything to gain from economic evaluation. For example an evaluation of competing uses of water and land would probably cast serious question on irrigation for agriculture since 92 percent of the western States' water is used for production of crops already in surplus supply. Multiple purpose projects are constantly overvaluing benefits and undervaluing costs. When we defend fish and wildlife everywhere and under all circumstances, we lose the confidence of legislators and the public.

KEYWORDS: Resource use, economics, user fee.

177. Crutchfield, James A.
1962. Valuation of fishery resources. Land Econ. 38: 145-154.

Determining the value of sport fishing, if nothing more than a measure of the cost of providing it, will not provide answers to crucial policy decisions. At most, expenditures will indicate the economic impact on local economies. Careful regional delineation and an "import-export" money flow is required to achieve a sound evaluation. Similarly, fisherman expenditures and a relationship of leisure hours to GNP are incorrect in principle. Conserving resources for recreational purposes, when viewed as an absolute and adhered to regardless of the strength of competing demands, is incorrect in principle and has not influenced public policy. A number of possibilities exists for valuation of all income-producing resources. Reasonable estimates of man-days and numbers of participants among the important sport fisheries is one. The use of differential fees might work on an experimental basis. The punch-card technique used for steelhead and salmon in Oregon and for steelhead in Washington could be put on a fee basis. There are strong grounds for arguing that sport fishing is grossly underpriced.

KEYWORDS: Economics, benefits, fishing, user fee, resource use, non-consumptive use.

178. Cunningham, David A., Henry J. Montoye, Helen L. Metzner, and Jacob B. Keller
1970. Active leisure activities as related to occupation. J. Leisure Res. 2(2): 104-111.

Relationships between occupational classes and participation in "active" leisure activities were studied by questionnaire among 1,648 working men, age 16 to 69 from Tecumseh, Michigan. Contrary to previous studies, little or no relationship was found between participation in active leisure activities and occupational grouping. Golf may be the only exception, with greater white-collar participation. Hunting and fishing participation percentages were 25 and 23 percent, respectively, second only to lawn mowing (40 percent) and gardening (29 percent). Blue-collar bias usually found among hunters and fishermen was not present.

KEYWORDS: Non-consumptive use, fishing, research methods.

179. Cushwa, Charles T., and Burd S. McGinnes
1963. Sampling procedures and estimates of year-round recreation use on 100 square miles of the George Washington National Forest. 28th Conf. North Am. Wildl. Nat. Resour. Trans. 28: 457-465, illus.

Mail questionnaires were sent to 1,532 recreationists who visited private camps, developed sites, and undeveloped areas. First-year results indicated that estimates of total use could be accurately made without knowledge of optimum allocation of sampling effort. Accuracy of estimates depends on selection of strata and efficient allocation of sampling effort. In this study approximately 700,000 man-hours of recreation use (including hunting and fishing) were examined in the light of area resources and recreation opportunities. Recreation use such as hunting, sightseeing, fishing, and primitive camping differed considerably from a nationwide survey which ranked first driving and walking for pleasure. Use was clearly related to the forest resource and the recreation opportunity available.

KEYWORDS: Research methods, fishing, Virginia, West Virginia, non-consumptive use.

180. _________ Burd S. McGinnes, and Thomas H. Ripley
1965. Forest recreation: estimates and predictions in the North River area, George Washington National Forest, Virginia. Va. Polytech. Inst. Dep. For. Wildl. Res. Bull. 558, 47 p., illus.

A total of 1,532 households were interviewed for information concerning use of a 100-square-mile study area. Developed-site camping, hunting, sightseeing, and fishing were the most important forms of recreation, with deer hunting providing by far the most hours of use. User attitudes most relating to participation were distance from the area, age, education, occupation, and income.

KEYWORDS: Research methods, non-consumptive use, Virginia, characteristics.

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181. Dahlberg, Burton L.
1959. Those good (?) old days. Wis. Conserv. Bull. 24(2): 25-28, illus.

Harvest statistics from the 1937 and 1957 hunting seasons in Wisconsin are contrasted. The 1957 season provided about a fourfold increase in harvest of deer for three times as many hunters as did the 1937 season. Greater harvest was accompanied by increased hunter pressure.

KEYWORDS: Crowding, Wisconsin, harvest statistics, big game.

182. Dahne, Robert A.
1960. Where does your dollar go? Fla. Wildl. 14(4): 29-32, illus.

Of every dollar in Florida's game fund, 49.5 cents goes to law enforcement, 23 cents to game management, 10.5 cents to fish management, 9.5 cents to information and education, and 7.5 cents to administrative and fiscal activities.

KEYWORDS: Economics, Florida, administration.

183. Dale, Fred H.
1961. Research problems in wildlife administration. J. Wildl. Manage. 25(3): 265-271.

Problems common to administrators and their research staffs are raised. These include personnel selection, training level, salary, research freedom, specialists in adjacent disciplines, and objectivity. The legitimate function of research is investigating factual relationships and interpreting cause and effect.

KEYWORDS: Research needs, profession, administration.

184. Dambach, Charles A.
1956. Is liberalized fishing a success in Ohio? Wis. Conserv. Bull. 21(9): 13-16, illus.

Liberal regulations have increased fishing opportunities. They have not increased the catch per hour but have resulted in larger fish caught without diminishing the fish population.

KEYWORDS: Fishing, management, Ohio.

185. _________ and Ernest E. Good
1939. Profits for the farmer. Soil Conserv. 4(9): 227-228.

Returns to the farmer from wildlife management are not all economic, but hunters take the biggest share of the game crop. Two systems of hunter control operate in the Ohio Valley. The Williamson Plan requires the hunter to obtain a ticket from a farmer before each hunt. The organization is generally built around some community enterprise. The Wood County System sells season permits to sportsmen at a range of prices, making the purchaser a member of the association. A part of the annual income is given to the community church or school, and the remainder is prorated to the farmers on an acreage basis.

KEYWORDS: Ohio, farmer-sportsman relations, historical value, management.

186. Dana, Samuel T.
1951. Wildlife in today's economy: social aspects. 16th Conf. North Am. Wildl. Trans. 16: 27-41.

Wildlife influences how man thinks, acts, and talks; it has both economic and social values for the community; it affects the personal characteristics of the individuals who hunt and fish; it is symbolically used by nations and football teams; and it influences art and literature. Although wildlife has been recognized as valuable by international treaty and is thrilling and appealing to the imagination and the emotions, it may be playing a decreasing part in the shaping of culture.

KEYWORDS: Non-consumptive use, benefits.

187. Danielson, Ephraim Alfred
1939. An analysis of farmer-sportsmen relationships as a guide to upland game management in the Willamette Valley, Oregon. M.S. thesis, Oreg. State Coll. 126 p., illus.

A personal interview and written questionnaire were used with 316 farmers and 193 sportsmen to determine social and economic factors operating in relation to hunting on farmlands. The farmers as a group were interested in upland game birds, but many birds are destroyed as a byproduct of normal farm practices. They also feared that large numbers of game would lead to many hunters and crop damage. Hunter-caused damage and too many dogs were the farmer's greatest problems. Sportsmen did not always ask hunting permission, but many said they had never been refused hunting privileges. Sportsmen believed that 28 percent of the birds were taken illegally by farmers. Sportsmen favored better law enforcement, even though they reported only 5 percent of the illegal hunting they observed personally. They believed that 22 percent more land was closed to hunting than was closed 10 to 15 years before. A majority of hunters were willing to offer inducement for hunting privileges, if farmers made an effort to practice game management. They preferred direct payments on a per-bird basis; the average willingness to pay was 24 cents per bird. Sportsmen and farmers gave suggestions to improve upland game hunting conditions.

KEYWORDS: Farmer-sportsman relations, economics, upland game birds, Oregon, preferences.

188. Dasmann, William P., Henry A. Hjersman, and Daly Gilsenan
1958. California's first general either-sex deer hunting season. Calif. Fish Game 44(3): 231-251, illus.

This article focuses on the 1956 hunting season: (1) to present a history of events leading up to the either-sex hunt, (2) to summarize the deer kill, (3) to outline the problems that arose during the hunt, and (4) to evaluate the 1956 harvest and the 1957 harvest. A total of 2,811 individuals and 49 organizations went on record as favoring the general either-sex hunt. Hunter distribution and behavior are given in very general terms. At one checking station 7,158 hunters were polled. Sixty-two percent favored the either-sex hunt, 27 percent opposed it, and 11 percent were undecided. After the hunt, public reaction was mixed, but strong opposition to the hunt forced legislation by which the Fish and Game Commission can no longer order general area-wide either-sex hunts. Such hunts must be ordered on the basis of management units, crop damage, or restricted instances of animal surpluses.

KEYWORDS: California, either-sex hunt, historical value, preferences.

189. Davey, Stuart P.

1967. The role of wildlife in an urban environment. 32d Conf. North Am. Wildl. Nat. Resour. Trans. 32: 50-60.

The function and role of wildlife resources in our society are changing. Desirable wildlife species can greatly improve the quality of the urban environment. State and Federal agencies responsible for wildlife resources can systematically direct the enhancement of wildlife species within urban areas through existing wildlife programs and improved coordination with city planners. Wildlife resources will also enlighten the public appreciation of our ecosystem. Wild animals will not be preserved even in wild places unless there is an interest among city voters.

KEYWORDS: Non-consumptive use, management, resource use, profession, urban wildlife.

190. Davis, Herbert C.

1939. Research and statistics applied to public relations. 31st Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 31: 88-91.

KEYWORDS: Public relations, education, California.

191. Davis, Robert K.

1964. The value of big game hunting in a private forest. 29th Conf. North Am. Wildl. Nat. Resour. Trans. 29: 393-403, illus.

Benefits of big game hunting in 5,000 acres of the Maine woods are defined by the sum of the maximum prices which the hunters would pay rather than be deprived of the privilege of hunting. Total willingness to pay was about $10.32 per household. Study estimates show the area has a social productivity of $29,000 as a hunting area or a public value equal to 8.6 percent of its private value. If the estimated willingness of hunters to pay is accepted as a measurement of the social value of hunting, then hunting is a significant social product of this land in relation to its private productivity.

KEYWORDS: Big game, economics, research methods, Maine.

192. Davis, William C.

1962. Values of hunting and fishing in Arizona, 1960. Univ. Ariz. Bur. Bus. Public Res. Spec. Stud. No. 21, 61 p., illus.

Interviews with 1,600 randomly selected hunters and fishermen in Arizona yield data on characteristics, motives, economic impact, and preference for additional services. Six categories of hunting and fishing are covered: cold and warm water fishing and big and small game, waterfowl, and general game hunting. Extensive data are presented in tables and graphs; appendix covers definitions, study assumption, methodology, and details of statistical analysis. Arizona's sportsmen spend over $40,000,000 each year compared with $2,000,000 by public agencies for recreation, health, esthetics, association, etc. (See Davis 1967).

KEYWORDS: Fishing, economics, preferences, harvest statistics, research methods, characteristics, Arizona.

193. ________

1967. Values of hunting and fishing in Arizona in 1965. Univ. Ariz. Coll. Bus. Public Adm. 91 p., illus.

Interviews in 1965 with 1,000 randomly selected Arizona sportsmen indicated 88 percent of the 276,500 sportsmen were State residents. Comparison with 1960 figures indicates that the proportion of young people entering the sport seems to be diminishing, although two out of three learned to hunt before the age of 20 and roughly half of these had participated in the sport for 20 years or more. Skilled and semiskilled workers composed 40 percent of the total sportsmen, managerial and office workers, 13 percent, and professionals and semiprofessionals, 10 percent. Incomes have risen since 1960; only 45 percent of the sportsmen had incomes of less than $7,000 per year. Total expenditures for 1965 were $63,227,900, more than 50 percent above 1960, with fishermen accounting for 62.7 percent of the total. "Recreation" was mentioned by 37 percent of the sportsmen as the primary reason for participation. "Economic value of game as food" was next with 15 percent, but it had increased 10 percentage points from the 1960 survey. "Bodily health" with 10 percent had decreased 13 percentage points from the 1960 survey. Esthetic, association, intellectual, character, and religious were other motivating forces of participation. Sportsmen were accompanied by nearly 1.5 million unlicensed companions on at least 10 percent of the hunting or fishing trips. Sportsmen reflected a favorable image (89 percent) of the Arizona Game Department but little knowledge of the Department's activities. The fish hatchery-stocking program was mentioned by 32 percent as excellent. The average sportsmen's knowledge of the function of the Game Department was "woefully limited." Only two services of the Department were correctly identified by over 50 percent of the sample. Sportsmen recommended regulation modifications, habitat and access improvement, and increased selective stocking. An equitable advance in license fees is suggested by this study. (Valuable as a comparison with the 1960 survey (Davis 1962).)

KEYWORDS: Fishing, economics, preferences, harvest statistics, research methods, characteristics, Arizona.

194. Day, Albert M.
1943. Wildlife contributions to the war. Am. For. 49(7): 326-330, 366-368, illus.

War needs for meat and hides have focused attention on byproducts of sportsmen's activities as an important economic asset. Although wildlife should make its contribution to the war effort, war should not be an excuse for unbridled exploitation of the resources.

KEYWORDS: Military, historical value, economics, benefits.

195. ________
1946. The problem of increased hunting pressure on waterfowl. 11th Conf. North Am. Wildl. Trans. 11: 55-66.

Propaganda concerning Ducks Unlimited along with other overselling and publicity have built a resistance in the minds of American hunters against any regulatory restraint. A current increase in hunting pressure exists at a time when the annual increase of fowl has already been overshot. Annual regulation is the only quick means of adjusting this pressure to supply.

KEYWORDS: Crowding, waterfowl, management.

196. Denmead, Talbott
1937. Legislative review, game and fish laws, 1937-38. 29th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 29: 16-20.

KEYWORDS: Legislation, historical value.

197. Dennett, Dan, and John Haygood
1966. Management areas hunts successful. La. Conserv. 18: 8-11, illus.

This educational article stresses the deer management advantages of of either-sex harvests on 15 Louisiana areas. Local hunter opposition has prevented these hunts until now and some groups still oppose them.

KEYWORDS: Big game, management, Louisiana, harvest statistics, either-sex hunt.

198. Denson, Eley P., Jr.
1964. Comparison of waterfowl hunting techniques at Humboldt Bay, California. J. Wildl. Manage. 28(1): 103-120, illus.

This comparative study (1959 and 1960 seasons) reveals that open-water shooters were more successful than land-based hunters, scullers were most efficient (one bird bagged per hunting hour), private club members bagged the most ducks per day averaging slightly less than the limit each, and pass shooters lost twice as many birds as they bagged. A review of regulations suggests revisions in pass shooting and pleasure boat controls.

KEYWORDS: Management, waterfowl, harvest statistics, California.

199. Dermid, Jack Franklin
1956. Techniques useful in photographing wild birds and mammals. M.S. thesis, Oreg. State Coll., 157 p., illus.

Before photography was attempted, a study was made of animal life histories to anticipate or lessen photographic difficulties. Remote control photography using the 4x5 Speed Graphic was found to be the quickest and easiest approach for quality night photographs. The Graflex camera proved best for flight photography while the Roleiflex was best for animals just released. The single-lens reflex was well suited to photography taken from blinds, particularly waterfowl shots. Different light sources are discussed, but flashbulbs provided a dependable, easily portable, and sufficient source of light in most cases. Various methods of camera mounting and remote control shutter tripping were examined. Methods are given for cleaning vegetation from around nests and in controlling foregrounds and backgrounds. Other discussion included: the possibility of moving nests to better photographic situations, the use of dummy cameras to condition animals, the use of introduced perches, the use of blinds, stalking, and jack-lighting techniques. The use of camera trips and their many shortcomings are discussed, as are techniques in placing cameras along trails at night. Plans for constructing a portable and permanent canvas blind are given.

KEYWORDS: Non-consumptive use.

200. De Roos, Robert
1960. The trout's mouthpiece. Sports Illus. 12(11): 64-65, illus.

University of California zoologist, Dr. Paul Needham, shows that many methods now practiced in the name of fish management to satisfy the fisherman's enormous appetite are wasteful. Most fishermen don't know how to fish: 5 percent of the fishermen catch 25 percent of the fish and 65 to 75 percent never catch fish. In 1959, 183 million trout were planted in the United States, costing $4 million and probably only 30 percent of these were recovered by fishermen.

KEYWORDS: Fishing, management.

201. Dickey, Charley

1957a. Shooting preserves in the south. 11th Conf. Southeast. Assoc. Game Fish Comm. Proc. 11: 34-38.

The article gives a general description of a private shooting preserve. Operators tend to tie up more land than they need: 1,000 acres is sufficient, but 100 acres is minimum. The State should exercise control over preserve operations, such as minimum bird release per season and licensing. Preserves are difficult to operate and there is no "fast money" to be made in them. Generally they are a full-time occupation by a single owner.

KEYWORDS: Surveys, landowner-private, legislation, plant and shoot.

202. _________

1957b. Shooting preserves in the United States. 22d Conf. North Am. Wildl. Nat. Resour. Trans. 22: 396-404.

States are encouraged to sanction shooting preserves that are privately owned and operated, with fees, extended seasons, and no bag limits on released game. State regulations should include a maximum acreage and a minimum seasonal release of each species. States are urged to issue special non-resident licenses to shoot on preserves, to make their own rulings on domestic ducks, and to cooperate with free enterprise to help meet sportsmen's demands.

KEYWORDS: Management, landowner-private, plant and shoot, refuge.

203. _________

1961. The future role of shooting preserves. 26th Conf. North Am. Wildl. Nat. Resour. Trans. 26: 247-253.

Preserve types, trends, regulations, operator-breeder liaisons, and management techniques are discussed.

KEYWORDS: Landowner-private, plant and shoot, refuge, management.

204. _________

1962. Shooting preserves in the west. 42d Conf. West. Assoc. State Game Fish Comm. Proc. 42: 132-136.

Shooting preserves are privately owned and operated areas where pen-raised game is stocked for hunting. A brief history of preserves is presented which points out that they are mainly for the benefit of the city hunter and they do not adversely affect either public game or public shooting. Discussion focuses on State legislation necessary for private preserves, state licensing, and characteristics of preserve operation. Three types of preserves are private clubs with closed membership, clubs which accept the general public, and preserves open to the public on a day-use basis.

KEYWORDS: Surveys, legislation, license fee, plant and shoot.

205. Dickinson, Nathaniel R., and C. W. Severinghaus

1969. The 1967 deer season in the Moose River Recreation Area. N.Y. Fish Game J. 16(1): 1-18, illus.

Of 6,457 hunters, 3,293 were holders of special antlerless deer licenses which quadrupled their chances for bagging deer. Although the take of 497 deer followed the typical pattern (high the first week, then dropping sharply), hunting success in terms of effort was best during the season's last 9 days. Most hunting was done within 1 mile of the road, with 97 percent of the total harvest coming from 60 percent of the area.

KEYWORDS: Big game, harvest statistics, New York, either-sex hunt.

206. Dieringer, Jack A.
1965. Economic values and conservation implications of fishing derbies. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 243-244.

Fish derbies involving awards have been used as a management tool to increase the return of tagged fish. Returns increased from 10 to 70 percent in a Lake Tahoe study. Cash awards of $1,500 are not great, especially when prizes are donated. Derbies involving planted fish for the exclusive use of children are discouraged because they do not foster good sportsmanship, nor the art of angling.

KEYWORDS: Fishing, economics, Nevada.

207. Dietz, L.
1967. Gunning Maine's ledges. Down East 14(4): 18-21, 44, illus.

Hunting for sea-ducks is more demanding than regular duck hunting. Sea-duck gunning may be the fastest of wing-shooting sports in the East. The activity takes place on rocky ledges overlooking the open sea. The hunter must also be a seaman to retrieve his game. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Waterfowl, Maine.

208. Dietz, Lew
1954. Woods detective. Sports Illus. 1(13): 54-56, illus.

A special investigator for the Maine Department of Fish and Game discloses many stories of his 10 years of investigating some 250 hunting accidents. He concludes that the veteran hunter is the greatest menace. In 219 accidents, 95 percent of the shooters were familiar with their firearms, 80 percent knew the country, and 86 percent had shot deer before. A good hunter has quick visual perception and conditioned reflexes to hear, see, and fire with deadly accuracy. Almost three-quarters of Maine's accidents occur in areas of low hunter density. Under such conditions the seasoned hunter often is psychologically prepared to see deer. In most cases he fires automatically and gets his deer, but often gets his fellow man.

KEYWORDS: Maine, accident, benefits, big game.

209. Dimmick, Ralph W., and W. D. Klimstra
1964. Controlled duck hunting in Illinois. J. Wildl. Manage. 28(4): 676-687, illus.

Data for 1957, 1958, and 1959 on two types of controlled areas operated by the Illinois Department of Conservation relate the amount of hunting provided to the costs of operation for the permit system (requires pre-registration and permit to hunt in State-constructed blinds) and the marked-blind-site system (allows hunters to build blinds and retain daily priority at marked sites). Total hunter utilization and annual hunting pressures were significantly greater on the latter areas, while the permit system distributed hunting pressures more equally. On the basis of man-days of hunting per unit area, marked-blind sites showed a more efficient use of space. Total waterfowl kill was higher on the marked-blind-site areas, although average daily bag was lower. Higher bag averages on permit areas were attributed to lower hunting pressure and to the influence of adjacent

private-club feeding and resting areas. Costs to the State were significantly greater on areas operated by the permit system, averaging $4.26 per man-day in 1957, $3.30 in 1958, and $11.66 in 1959; marked-blind-site areas averaged $0.59, $0.75, and $1.74 per man for the respective years.

KEYWORDS: Management, waterfowl, economics, harvest statistics, Illinois.

210. Donlin, Bob
1959. Montana's hunter safety program. 39th Conf. West. Assoc. State Game Fish Comm. Proc. 39: 369-373.

Methods and results of Montana's safety program are given. Education is the most important tool to combat firearm and hunting casualties. Young hunters are required by legislation to take a gun-handling course before securing a big game hunting license.

KEYWORDS: Safety, education, Montana.

211. Dorian, Henry
1965. The economic value of the chukar partridge to Nevada. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 55-56.

Decline in Nevada's sage hen population prompted release of chukar partridges in 1935. The chukar inhabits range which was previously deficient in other species of game birds and is now the State's number one upland game species. In 1964, more than 11,000 sportsmen hunted chukar. Assuming that each chukar hunter spent an average of $25 in his quest for the bird in 1963, the economic impact on purchasing would have been $275,000. Adding the estimated value of the birds harvested ($2 per bird), the total value comes to $529,000. Total economic impact of chukar hunting during the years 1951-63 would be about $2,704,550 or $208,000 per year.

KEYWORDS: Upland game birds, Nevada, economics, harvest statistics, benefits.

212. Drahos, Nick, and Roy Irving
1954. New York's first 2-deer special season. N.Y. State Conserv. 9(2): 26-27, illus.

Diary account of 800 people waiting in lines to apply for a special antlerless deer and one buck permit.

KEYWORDS: Big game, either-sex hunt, preferences, New York.

213. Drumaux, L.
1925. Forests, hunting, and fishing from the economic viewpoint in Belgium. J. For. 23: 670-676.

The organization and value of wildlife to forest management in Belgium are highlighted. Belgium income from hunting for 1922 was 9,390,000 francs. The value of game was 16,500,000 francs while commerce in guns, ammunition, and equipment for Belgian hunters was 7,000,000 francs. Total income from hunting was 37,730,000 francs. This total does not include subsidiary values to dog raisers, hotels, or merchants. Products of river and stream fishing during 1922 were 65,000 francs for leasing, 419,000 francs for permits and licenses, and 7,500,000 francs for the value of the fish--a total of 7,984,000 francs. Benefits from custom duties on hunting and fishing were 52,830,833 francs for the same year.

KEYWORDS: Economics, Belgium, fishing, benefits, historical value.

214. Drury, Newton B.
1952. Recreation--natural--aesthetic values. 17th Conf. North Am. wildl. Trans. 17: 62-71.

The recreational, natural, and esthetic aspects of wildlife can be best used in terms of experiences and observation. The concept of protection of scenery and nature conservation reaches its highest phase in the National Park system which is an exception to the usual treatment of public lands. Recreation is a byproduct of the management processes of many Federal and State agencies. A Federal policy on parks and recreation and wilderness preservation should emphasize the national aspect of recreation areas and should also appraise the duty and capability of the States and of local, county, and regional planners. Conservation of nature including wildlife is an essential part of the American tradition, a gage of the national dignity, and an assurance of national health and sanity.

KEYWORDS: Conservation, non-consumptive use, esthetics.

215. Duggan, Alfred
1957a. The lady and the trout. Part I. The lady and the trout: the writing of the "treatise." Sports Illus. 6(19): 75-87, illus.

An eminent medievalist and author discusses Dame Juliana Berners, a 15th century English nun who launched five centuries of sport and literature. This first of four parts reviews Dame Berners' life and writings in fishing. Her writings describe every known method of fishing without a net. (Also see Duggan 1957b, McDonald 1957, McDonald and Webster 1957.)

KEYWORDS: Fishing, historical value, England, literature.

216. ________
1957b. Part II. The lady and the trout: the treatise of fishing with an angle. Sports Illus. 6(20): 72-79, illus.

A new rendering of Dame Juliana's original text is presented on why fishing is the best of all sports, on how to prepare the necessary equipment, and how to lure and catch the fish you seek. (Also see Duggan 1957a, McDonald 1957, McDonald and Webster 1957.)

KEYWORDS: Fishing, historical value, England, literature.

217. Durbon, William B.
1965. Eye tests for hunters? 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 42-49.

Accidents are typically caused by males 20 years and older having 3 or more years of experience. Forty percent of the casualties took place during small game hunts and occurred in the afternoon under clear visibility. An insurance company rates hunting 16th on the list of dangerous sports. The National Uniform Hunter Casualty Report could require determination of the visual status of the shooter involved. Such information, properly collected and carefully analyzed, should be a prerequisite and the basis for consideration of a compulsory visual ability test. Author does not believe that visual problems play an important role in hunting accidents.

KEYWORDS: Safety, accident.

218. Durbon, Wm. B.
1968. The nonresident--friend or foe? 48th Conf. West. Assoc. State Game Fish Comm. Proc. 48: 91-97.

Any non-resident policy of discrimination of "fee upmanship" endangers the concept of State's rights and encourages an unwanted national license program. Restrictions placed on nonresidents in other States would not work in Idaho because they would result in under-harvest of vast back-country areas, and resident fees would be increased if the non-resident revenue were lost. Idaho's non-resident hunter currently pays 53.7 percent of the hunting bill but takes only about 10-12 percent of the game. In a mobile society, people are not hampered by distance, and State commissioners must provide opportunity for residents and nonresidents alike to avoid Federal intervention.

KEYWORDS: License fee, Idaho, Federal-State jurisdiction, resident vs. nonresident.

219. Durell, James S.
1962. A study of Kentucky hunters who hunted only in their home counties. 16th Conf. Southeast. Assoc. Game Fish Comm. Proc. 16: 171-175.

The license fees of the enthusiastic hunter do not support the deer and waterfowl programs he often demands. The vast majority of casual hunters must make up these deficits. Hunters hunting in their home counties were thought to be less enthusiastic than those who traveled further. Questionnaires and interviews of 1,176 home-county hunters showed little variation from the statewide average. A survey of all hunters in Kentucky in 1961-62 indicated 90 percent of the hunters sought only small upland game hunting. Only 47 percent of the hunters left their home counties to hunt, and only 28 percent went farther than the adjoining counties.

KEYWORDS: Kentucky, characteristics, preferences.

220. ________
1967. A brief study of hunters and the owners of the land on which they hunt. 21st Conf. Southeast. Assoc. Game Fish Comm. Proc. 21: 81-87.

Data and statistics on hunting were examined to determine why fewer hunting licenses were bought in Kentucky in 1966 than in 1957. Questionnaires were mailed to 2,335 hunters (1 percent of the license holders), who returned about 46 percent of those mailed. These hunters indicated 92 percent of their hunting was on private land and only 25 percent had used public land. The State's most productive game areas are in remote country; by concentrating management on these areas, Kentucky has benefited only 25 percent of the hunters and less than 10 percent of the hunting. Private landowners provide 92 percent of the hunting privileges. Hunting on private land is essential to this valuable sport and perhaps to the survival of the wildlife profession.

KEYWORDS: Crowding, landowner-private, Kentucky, characteristics, economics.

221. Duryea, Perry B., and William E. Tinney
1952. Game laws--and law enforcement. N.Y. State Conserv. 7(2): 2-3.

New York regulates the sportsman principally through legislation.

Regulations are voluminous, complicated, and hard to follow. There is need for simple, clearer, and more enforceable laws.

KEYWORDS: New York, legislation, enforcement.

222. Duthie, George A.
1929. Relation of land ownership to ownership of wild life. J. For. 27(3): 264-266.

In Europe the landowner also owns the game. In the United States it is contrary to the principles of a democratic government that a few individuals should own a natural resource to the exclusion of the general public, and game is supervised, protected, and regulated by the States. The public interest should be the basis for any answer to the question of State or Federal regulation. The chief trouble with State control has been political, but Pennsylvania and New York are noted for non-partisan wildlife administrations. When wildlife problems are wider than State lines, then Federal control is in the public interest. Federal control is unnecessary when a State's administration is inefficient; public sentiment reform will suffice.

KEYWORDS: Landowner-private, Federal-State jurisdiction.

223. Dyber, John Andrew
1948. A proposed college course for teaching the theory and techniques of fresh-water fishing. M.E. thesis, Springfield Coll., Mass., 139 p., illus.

The syllabus was developed for a three-term college course to cover information pertinent to New England. Fall term emphasis is on historical background, conservation practices, natural history of fish and theory and technique of bait casting. Winter term stresses ice fishing, natural history of aquatic insects, and the theory and technique of tying artificial flies. Spring term stresses care and repair of equipment, streamcraft, and the theory and technique of fly casting. (References provided, 16.)

KEYWORDS: Fishing, education.

224. Dyer, A. Allen, and R. S. Whaley
1968. Predicting use of recreation sites. Utah State Univ. Utah Agric. Exp. Stn. Bull. 477, 21 p.

The study attempts to predict recreation use at two fishing sites and in a campground in Utah through the use of predictive models developed for shopping-center market analysis. Relevant factors influencing the choice of recreation opportunity included opportunities available at the site, competing opportunities, and travel distance. Step-wise deletion multiple regression analysis was used to identify variables in the use prediction model. Seventy-four percent of the variation in use of the two streams can be accounted for by the above independent variables. Respondent age, income, and the percentage of urban population added little to the ability to predict recreation site use. The authors indicate the difficulty in developing generalized prediction equations for various kinds of recreation sites or for the same kind of site in different geographic areas. (Study deserves attention by managers and researchers interested in site selection and recreation valuation.)

KEYWORDS: Fishing, Utah.

225. Dyer, Archie Allen
1968. The value of a trout stream fishery. M.S. thesis, Utah State Univ., 50 p., illus.

Personal interviews with Utah trout stream fishermen were used to calculate consumer's surplus in order to evaluate the economic value of fishing. This method considered cost-per-mile traveled, length-of-stay, and hours fished. Results show that the capitalized value of annual gains are in excess of $88,600 for one creek and $118,600 for another. These values must be exceeded before other uses can have priority.

KEYWORDS: Economics, Utah, fishing, resource use.

226. Dziedzic, Eugene S., and J. Burton Lauckhart
1966. Feel free to hunt. 46th Conf. West. Assoc. State Game Fish Comm. 46: 239-244.

A new concept, "Feel free to hunt," was possible because authority to enforce signs posted on private lands owned or leased by the Department of Game was recently provided for in Washington's Game Code. A pilot program in the Columbia Basin tested this concept and found it favorable. The cost was 10 cents per acre. This entire approach is based on the policy that free hunting is most desirable.

KEYWORDS: Resource use, user fee, landowner-private, Washington.

E

227. Eabry, Steve

1970. Distribution of big game licensees in New York. N.Y. Fish Game J. 17(2): 88-94, illus.

About 8.5 percent or 44,498 of the big game and archery licenses sold in 1965 were sampled. Fifty-seven percent of the licenses sold were from rural zones where 19 percent of the population resided. In contrast, 43 percent were from urban zones where 81 percent of the population resided. Nonresidents came from 23 States. An average of 35 persons did not buy a license to hunt big game for each one person who did. The proportion was much higher in urban areas than in rural areas, ranging to 167 in New York City.

KEYWORDS: New York, resident vs. nonresident, crowding.

228. East, Ben

1972a. The big lie. Outdoor Life 149(6): 65-67, 100, 103, 104, 106, illus.

Television, the most influential of the mass media, has been used to escalate nationwide antihunting sentiment. The film "Say Goodbye" was to be a documentary on endangered wildlife species, but it actually portrayed hunters as ruthless killers and hunting as the cause of most wildlife problems. More than one sequence was staged or phony. Three law suits were brought against the production, but a congressional hearing did little to repair the damage done in the public mind. The sponsor received over 50,000 letters praising the film against about 20 attacking it. Few of America's 20 million hunters challenged the TV show. Through 1971, television and radio continued their attack on hunting. Another film titled "Animal World" charged hunters with the plight of the whooping crane. Another television show suggested that the national crime rate would drop if all hunters turned in their guns. Only token effort was given to obtaining rebuttals from wildlife-oriented or sporting-goods people. American hunters must take action by voicing objections to media that mislead an uninformed public about the relationship between hunting and wildlife. TV films have shown very atypical hunting situations and yet have seriously threatened sport hunting.

KEYWORDS: Antihunting, public relations, communications, legislation.

229. __________

1972b. The big lie: Part II, four-alarm fire. Outdoor Life 149(7): 56-57, 92-97, illus.

Attacks are being made against hunting in State legislatures, the U.S. Congress, and the courts by protectionists who decry killing. There is much ignorance of biological game principles. Hunting is necessary for the proper management and well-being of wildlife. No species under modern management has become endangered or extinct. In 1971 court actions and legislation outlawing the killing of various game animals were either introduced or passed in 10 States. One organization has attempted to restrain controlled hunts in New Jersey, Virginia, and Maryland. A precedent could jeopardize all State and Federal use of controlled hunts to reduce surplus populations of big game. It is imperative that sportsmen's groups contact these organizations and keep the lines of communication open.

KEYWORDS: Antihunting, communications, legislation, public relations.

230. ________
1972c. The big lie: Part 3, It's time to act. Outdoor Life 150(2): 51-53, 116, 118-120, 122, illus.

The first 2 years of this decade have witnessed the launching of a well organized program to bring hunting to an end by law. This campaign has resorted to falsehood and misrepresentation to delude millions of uninformed people into believing that hunting is cruel, wasteful, and contrary to conservation. Hunters forged the Nation's conservation movement by financially supporting Federal conservation programs long before the word "ecology" became popular. Sportsmen's license fees yielded nearly $200 million in the United States last year, and excise taxes on arms, ammunition, and tackle provided an additional $48 million. If hunting were outlawed, conservation funds from that source would die out. The antihunting movement can be met by communicating to the public a basic understanding of the ecology of game populations. Fundamental changes are required in hunter attitudes, shooting regulations, and proficiency in firearms handling.

KEYWORDS: Antihunting, management, legislation, public relations, education, communications.

231. Eberhardt, Lee
1960. Estimation of vital characteristics of Michigan deer herds. Mich. Dep. Conserv. Game Div. Rep. No. 2282, 192 p., illus.

Detailed comparison was made of three methods of estimating deer population levels. Data from the sex-age-kill method and hunting effort demonstrated that vulnerability to hunting is not constant. There is a sharp decline in vulnerability during the first week of hunting season and an inverse relationship between number of hunters per unit area and hunter efficiency.

KEYWORDS: Big game, Michigan, research methods, management.

232. Eckles, T. V.
1951. The unwise catering to pressure group demands. 41st Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 41: 58-61.

Action toward pressure group demands may be the greatest indicator of progress made by game and fish commissions. Some requests by pressure groups form a precedent. Adopting such demands often means complete disregard for financial and biological limitations. The unsound policy of catering to pressure groups has many ill effects, especially when it "reduces the confidence of worthwhile personnel." All proposals should be considered on their merits. Failure to adopt a scheme must be concrete and presented only after completion of an unbiased survey. New educational programs with biological truths afford great possibilities in meeting pressure groups.

KEYWORDS: Administration, preferences, clubs.

233. Edson, Marshall
1949. The hunter's choice in big game management. 29th Conf. West. Assoc. State Fish Game Comm. Proc. 29: 122-128.

Paper is mostly oriented toward the animal resource but has a brief history of either-sex hunting in the United States. (Literature cited, 7.)

KEYWORDS: Big game, either-sex hunt, management, harvest statistics, Idaho, historical value.

234. Edwards, R. Y., and C. D. Fowle
1957. Harmony or discord? A critical look at wildlife management. J. Wildl. Manage. 21(3): 349-350.

Wildlife management is emerging from an era of laws, regulations, predator control, and game farms. It is a specialty, but to succeed it must recognize social, economic, and biological factors in its own and related fields. Wildlife production is not controlled by wildlifers but by foresters, farmers, city planners, engineers, and others who modify the land and greatly influence the quality and composition of wildlife habitats and populations. Because a wildlife manager has little control over land, he must integrate activities with the other land users even though others have little to gain from integration with wildlife management. Current concepts of good land use and wildlife management assume that benefits to man are spiritual and social as well as economic. Wildlife management will succeed if the gap is narrowed between what people would get without wildlife management, and what they want and need. A biological and ecological knowledge of wildlife is not enough to achieve this goal.

KEYWORDS: Philosophy, profession, non-consumptive use, management.

235. Einarsen, Arthur S.
1939. Oregon's open season on antelope in 1938. 4th Conf. North Am. Wildl. Trans. 4: 216-220, illus.

Depending on antelope concentrations, 300 permits were issued among three counties for the 5-day open season. Extreme success (72.34 percent) indicates necessity for a short, controlled season on the antelope after a period of protection. Hunter party numbers should be limited. Game stalking is preferred to mass shooting, and powerful guns are required to bag an antelope.

KEYWORDS: Management, harvest statistics, Oregon, big game.

236. Eisele, Timothy T.
1970. Wisconsin waterfowl hunter attitudes on regulations and management policies. M.S. thesis, Univ. Wis., 123 p., illus.

Questionnaire responses from 442 Wisconsin goose and duck hunters provided the following data: hunters averaged 16 years of experience, spent 10 days hunting, and bagged 11 ducks during the 1969 season. A true-false test indicated that hunters are well informed. Hunters favored species-oriented regulations, Wisconsin's present goose tagging system, and 10 extra days in the hunting season rather than a larger bag limit. Most hunters derived their waterfowl information from newspapers, the State Department of Natural Resources, and magazines. Another test showed the Department knew hunters' attitudes more often than hunters knew the Department's attitudes. (An expanded abstract of this thesis appears in *The Journal of Environmental Education* 1972, 4(1): 22-25.)

KEYWORDS: Characteristics, management, preferences, waterfowl.

237. Elder, William H.
1946. Implications of a goose concentration. 11th Conf. North Am. Wildl. Trans. 11: 441-446.

In 1927, the Illinois Conservation Department developed an island refuge at Horse Shoe Lake where corn and wheat were planted to attract

Canada geese. By 1941 thousands of geese had congregated and become oblivious to danger. Land surrounding the lake was rapidly developed by commercial goose shooting clubs. Hunter numbers increased from a few hundred in 1934 to 5,000 in 1944. Limitations imposed by Federal and State authorities, including reducing the bag limit from five to two birds and the season from 60 to 5-1/2 days, have failed to keep the kill within reason. Before other States develop concentrations of geese, there must be serious consultation between State and Federal officials, biologists, and enforcement officers.

KEYWORDS: Management, Illinois, refuge, waterfowl.

238. ________
1965. Primeval deer hunting pressures revealed by remains from American Indian middens. J. Wildl. Manage. 29(2): 366-370, illus.

Deer jaws from Indian middens available from five prehistoric and historic deer populations in Missouri are compared with two contemporary samples from areas where either-sex deer hunts are legal. Findings show that a light fawn kill by Indians (8 percent of population contrasted with 30 percent for modern hunting) may reflect a voluntary conservation practice by Indians, modern deer populations are being more closely cropped, and the proportion of old deer in the harvest is declining. The proportion of old deer reflects a definite trend: 20-26 percent for prehistoric times, 3-11 percent for historic times, and only 2 percent in modern times. Rapid population turnover in contemporary deer populations indicates that equipment and rapid transportation enable modern man to exert a greater hunting pressure during a 1-week season than Indians did by hunting year-round.

KEYWORDS: Anthropology, tradition, crowding, harvest statistics, big game, historical value, conservation.

239. Elkins, W. A.
1952. Pressing problems in administration of wildlife resources in Alaska, p. 268-281. *In* Science in Alaska, Conf. Natl. Acad. Sci. Res. Counc., 1950. North Am. Montreal: Arctic Inst.

One section of this paper deals with problems created by human populations. The three most important problems are: the influx of transients who hold the "get it now--we won't be here tomorrow" attitude; those related to the economy of the native people, if they are bound to the same laws as white men even though their existence depends on fur, fish, and game; and lastly, problems caused by competition for traplines. One problem Alaska does not have is closed land; only 2 percent of Alaska's total land area is closed to hunting.

KEYWORDS: Alaska, access, management, native claims.

240. Ellefson, Paul V., and Gale C. Jamsen
1971a. Economic appraisal of Michigan's sport fishery, January 1-April 24. Mich. Dep. Nat. Resour. Res. Dev. Rep. No. 227, 36 p., illus.

Salmon, steelhead trout, and other sport fisheries were evaluated utilizing distance traveled, number of angler days, and fisherman expenditures. These data were fitted to Clawson-type recreation demand curves. The economic value of the salmon-steelhead fishery totaled $587,600. The value of other sport fishing resources was estimated at $5.1 million.

Fishermen spent an average $33 on all trips taken during the study period, they averaged 5 days of fishing, their average income was $9,838, and their average age was 38 years.

KEYWORDS: Fishing, Great Lakes, economics, Michigan, characteristics.

241. ________ and Gale C. Jamsen
1971b. Michigan's salmon-steelhead trout fishery: an economic evaluation. Mich. Academician 4(2): 237-244, illus.

Travel costs and average distance that anglers drive in getting to fishing sites were obtained from a mail questionnaire survey. These data were fitted to Clawson-type recreation demand curves. The net economic value of the resource was estimated to be $8.34 million. Fishermen from the southeast portion of the State traveled the greatest distances and spent the most money per day fished, while fishermen in the north-central portion of the State traveled the least and had the lowest cost for each day fished.

KEYWORDS: Michigan, economics, Great Lakes, fishing.

242. Elrod, Joseph H., and John R. Kelley, Jr.
1966. Cost analyses of sport fishing in commercial catfish ponds. 20th Conf. Southeast. Assoc. Game Fish Comm. Proc. 20: 273-278, illus.

Over a period of about 6 months, 1,434 of the 13,528 people who fished on the Auburn University Fisheries Research Unit ponds were interviewed as they fished to determine selected expenditures per trip. In addition to the $1 pond permit fee, fishermen spent $1.25 per trip for travel and $0.89 per trip for bait and equipment. Average distance traveled round trip was 34.5 miles. Total expenditures were estimated to have been $42,628 for 150 days of fishing. Permit expenditure was $13,528, bait expenditure $6,872, equipment $5,297, and travel expense $16,931. The gross expenditure was $1,740 per surface acre of water.

KEYWORDS: Economics, fishing, Alabama.

243. Emerson, Frederick B., and James H. Burbank
1967. Landowner feelings about wildlife in the Tennessee Valley. 21st Conf. Southeast. Assoc. Game Fish Comm. Proc. 21: 88-94, illus.

TVA foresters polled 676 private landowners in 1964 for information about tree planting and game development. The survey covered 31.2 million acres of private land in 397,100 ownerships. Forty-one percent of the owners hunt, 69 percent allow hunting without qualification, and 15 percent would allow hunting with permission. Over 26 million acres are potentially open to hunting. Thirty-six percent are willing to improve their lands for game at their own expense if given free professional advice.

KEYWORDS: Surveys, landowner-private, access.

244. Empey, LaMar T., and Walter L. Slocum
1955. Stability of farmer's attitudes in a conflict situation involving farmer-hunter relations. Rural Sociol. 20(3-4): 242-248, illus.

Responses were obtained from 190 farmers (100 percent of the population) in a before-and-after analysis of farmers' attitudes in a conflict situation.

Most farmers were not influenced by a group organized to influence opinion and action. Farm ownership and previous traumatic experience with hunters were found to be associated with the farmers' decisions to restrict hunting. Data support the hypothesis that actual experience with a situation tends to reduce prejudice against it. It is concluded that: attitudes, if defined as internalized predispositions to act, tend to be stable, although verbalized responses tend to be unstable; changes in attitudes often involved the activation of previous experiences; predispositions to act were not necessarily more typical of individuals in whom cross-pressures operated; and opinion leaders did not influence the decision of most farmers.

KEYWORDS: Landowner-private, farmer-sportsman relations, preferences.

245. Erickson, David L.
1970. Attitudes and communications about wildlife. 35th Conf. North Am. Wildl. Nat. Resour. Trans. 35: 372-383, illus.

An effective message is one that is designed for an audience characterized by a type of attitude. Q-methodology was used to determine the attitude types of 49 persons consisting of hunters, farmers, watchers, and "other." Two wildlife-attitude types were identified: "protectionists," those who want to save vanishing wildlife, and "reductionists," those who view many wildlife as destructive to agriculture. Protectionists are more likely to be watchers and "other" than hunters; farmers are more apt to be reductionists but hunters and watchers are not. Results have implications for management policy and communication design.

KEYWORDS: Communications, management, preferences.

246. _________ and G. Norman Van Tubergen
1972. "The wolf men." J. Environ. Educ. 4(1): 26-30.

An estimated 16,000 letters were written in response to "The Wolf Men," a television documentary, intended to create a concern for the preservation of timber wolves. The Bureau of Sport Fisheries sampled 320 of the first 1,600 letters they received. Results indicate that most letter writers believe that all subspecies of timber wolves are endangered and they want government action to protect wolves from hunting. Most believe that the bounty system serves as an incentive to the wolf's demise. While 38 percent mentioned opposition to the hunting of wolves per se, 35 percent opposed only hunting from aircraft as shown in the movie. The most prevalent reason (35 percent) given for protecting the timber wolf was that it is part of our American heritage and part of nature. A significantly greater proportion of women responded to the TV program than men, and a higher proportion of the letters came from the West than from the South. Wildlife agencies should work with film producers to insure that factual information is communicated. For example, it is only the eastern timber wolf, not all wolves, that is classified as endangered. Writers were also uninformed about Federal versus State jurisdiction over wildlife.

KEYWORDS: Predator, communications, education, preferences.

247. Erickson, David Lee
1969. Attitudes about wildlife and preferences in television programs: a communication study. Ph.D. diss., Ohio State Univ. 185 p.

The study was designed to hypothesize the relationship between attitudes toward wildlife and selected demographic and other characteristics and the

relationship between types of wildlife attitudes and types of television program preferences. Q-methodology was used for determining attitudes and preferences. Three types of persons evolved. The "protectionist" was primarily concerned about saving vanishing wildlife and protecting it from hunting; the "reductionist" views much wildlife as destructive to agriculture and favors hunting and controls; and the "balance of nature" type perceives predators and controlled hunting as important in maintaining a balance. "Protectionists" are more apt to be watchers and nonhunters, and farmers are apt to be "reductionists." The four types of television programs preferred were labeled: "believable-moral intellectual," "believable-conflict," "unbelievable fiction," and "believable fiction-low complexity." The protectionist type is most related to the believable fiction-low complexity type. The reductionist type was slightly related to the believable-conflict type. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Preferences, management, communications.

248. Errington, Paul L.
1940. On the social potentialities of wildlife management. J. Wildl. Manage. 4(4): 451-452.

Wildlife management is essential to human welfare in its economic and recreational aspects. It also offers consistent parallels between humans and wildlife in population phenomena and behavior. If man ever learns to manage himself, some of the foundation may have been laid by workers in this and other ecological fields.

KEYWORDS: Profession, philosophy, management, benefits.

249. ________
1947. A question of values. J. Wildl. Manage. 11(3): 267-272.

Intangibles are often the greatest "trophies." The appeal, with or without a gun, of the out-of-doors is conditioned by diversity and completeness of native fauna and flora. Management mistakes include altering the landscape that should be left alone, and "vermin control." Wildlife management must safeguard even unpopular species. Hunting is logically justified only when it is not detrimental to both game and non-game species, which means that the hunting toll must be confined to biological surpluses. The wildlife profession should accept broader responsibilities for non-consumptive outdoor values.

KEYWORDS: Antihunting, management, esthetics, predator, non-consumptive use.

250. Eschmeyer, R. W.
1937. The Michigan creel census. 2d Conf. North Am. Wildl. Trans. 2: 625-634.

Discussed are the general creel census and the intensive census which gave such data as fisherman catch per hour and per day, sex and residence of the angler, empty creels, effectiveness of methods and baits, time of day, and type of weather.

KEYWORDS: Fishing, harvest statistics, Michigan, characteristics.

251. ________
1955a. Fish conservation fundamentals; part three: regulations. Fla. Wildl. 8(12): 28-29, 47, illus.

KEYWORDS: Conservation, management, fishing, enforcement.

252. ________
1955b. Fish conservation fundamentals; part 6: creating more fishing waters. Fla. Wildl. 9(3): 22-23, illus.

KEYWORDS: Conservation, landowner-private, management, fishing.

253. ________
1955c. Fish conservation fundamentals; part seven: using the tools. Fla. Wildl. 9(4): 24-25, illus.

KEYWORDS: Conservation, education, administration, preferences, profession, research needs.

254. ________
1955d. Fish conservation fundamentals; part 8: commercial fishing. Fla. Wildl. 9(5): 28-29, illus.

Covered are monetary values, employment, and intangible values of sport fishing versus commercial fishing. The conclusions are that fish are more valuable when taken by sport fishing; and where fish supplies are inadequate for both kinds of fishing, the commercial fishing must give way to angling. Economic data are from four western States and the Chesapeake Bay in Maryland.

KEYWORDS: Conservation, economics, fishing, management, benefits.

255. ________
1955e. Fish conservation fundamentals; part 9: research. Fla. Wildl. 9(6): 18-19, 40, illus.

KEYWORDS: Conservation, research needs, fishing.

256. ________
1955f. Fish conservation fundamentals; part ten: education. Fla. Wildl. 9(7): 14-15, illus.

KEYWORDS: Conservation, fishing, education, communications, public relations.

257. ________
1956a. Fish conservation fundamentals; part eleven: the value of angling. Fla. Wildl. 9(8): 30-31, illus.

KEYWORDS: Conservation, fishing, economics, esthetics, surveys, benefits.

258. ________
1956b. Fish conservation fundamentals; part 12: the modern program. Fla. Wildl. 9(9): 26-27, illus.

KEYWORDS: Conservation, administration, profession, management, education.

259. ________
1956c. Fish conservation fundamentals; conclusion: the sportsman's role. Fla. Wildl. 9(10): 22-23, illus.

KEYWORDS: Conservation, preferences, clubs.

260. Evison, Lee Earl
1971. Pheasant hunters at western Washington regulated hunting areas: characteristics, motivations, and opinions. M.S. thesis, Univ. Wash. 62 p., illus.

Questionnaires and followups were sent to 1,296 regulated hunting area hunters, who gave a return rate of 87.9 percent. Results indicate that most hunters preferred to hunt upland game or waterfowl, 96 percent of them were male, and 74.4 percent were between the ages of 25 and 65. Thirty-three percent had attended or graduated from college, and 9.3 percent had postgraduate college training. Half the hunters lived in a large city or suburb. Annually, 47.2 percent of the hunters earned $12,000. Availability of game accounted for 36.5 percent of the first-listed reasons for hunting regulated areas, convenience accounted for 30.8 percent, and access was listed by 21.8 percent. Of the hunters who listed problems of the areas, 58.6 percent mentioned crowding and 10.9 percent mentioned scarcity of game.

KEYWORDS: Management, Washington, research methods, characteristics, preferences, upland game birds.

261. Evrard, James O.
1970. Testing and teaching waterfowl identification. Environ. Educ. 1(4): 119-120.

The success of waterfowl species management depends largely upon the hunter's ability to identify waterfowl in flight and to refrain from shooting protected species. A study of 20 experienced and 20 novice hunters in 1967 indicated that many hunters cannot shoot selectively. The experienced hunters correctly identified seven out of 10 ducks, while the novice hunters identified only five out of 10 birds and generally performed below the levels required by selective shooting regulations. In 1968, 33 hunters of average experience and comparable skill completed a field identification training program before being field tested. The hunters "shot" waterfowl with a 35-mm. camera, the photos being used to check their identification and the estimate of range. The trained hunters correctly identified eight out of 10 waterfowl and the untrained hunters seven out of 10, but both did poorly on range estimation, "shooting" three out of 10 ducks beyond effective killing range of a 12-gage shotgun.

KEYWORDS: Waterfowl, education, research methods.

F

262. Faass, Norbert C.
1958. How the States can more adequately enforce the license provisions against non-qualified holders of resident licenses. 38th Conf. West. Assoc. State Game Fish Comm. Proc. 38: 306-307.

KEYWORDS: Law violation, enforcement, administration, resident vs. nonresident.

263. Farley, John L.
1956. National survey of fishing and hunting. 46th Conf. Int. Game Fish Conserv. Comm. Proc. 46: 191-196.

Background information is given on the 1955 National Survey of Fishing and Hunting. (See U.S. Bureau of Sport Fisheries and Wildlife 1955.)

KEYWORDS: Fishing, economics, surveys.

264. Fine, I. V., and E. E. Werner
1960a. Economic significance of hunters in Wisconsin. Univ. Wis. Bur. Bus. Res. Serv. I(6), 16 p.

Separate questionnaires were mailed to big game hunters, small game hunters, voluntary sportsmen, and bow and arrow hunters. Returns ranged from 36.6 percent to 66.1 percent. Data reveal that an average of 1.94 overnight trips were taken by all license holders in 1959. Hunters tend to use non-commercial accommodations. In 1959, hunters spent approximately \$75,184,809 for hunting expenditures (fees, clothing, amusements, accommodations, meals, and transportation) and \$57,789,206 on equipment. Approximately 40 percent of all hunters attempted to secure information about hunting facilities. Sportsmen who operated boats mentioned launching facilities as the most frequent improvement needed. More than 55 percent of big and small game hunters were in the less than \$6,000 income brackets, whereas the opposite is true of the bow and arrow hunters.

KEYWORDS: Archery, characteristics, Wisconsin, economics.

265. _________ and E. E. Werner
1960b. Economic significance of fishing in Wisconsin. Univ. Wis. Bur. Bus. Res. Serv. I(10): 10 p.

Mail questionnaires were sent to 4,000 resident and 4,000 non-resident fishing license holders from Wisconsin. The questionnaire return rate was a very low 30 percent. The non-resident fishermen took more trips and stayed longer than resident fishermen. More than 40 percent stayed in commercial overnight accommodations. Approximately \$188 million was spent for fishing, and nonresidents spent about one-third more than the resident fisherman. Four out of 10 fishermen reported that they attempted to secure fishing information and of these, 77 percent were successful in getting information. Suggestions for improving boat facilities are listed. Fisherman occupation, income, and age are also listed. (Questionnaire is included.)

KEYWORDS: Fishing, economics, Wisconsin, characteristics.

266. Fish and Wildlife Studies Committee
1971. Fish and wildlife appendix XIV. 453 p., illus. *In* Columbia-North Pacific Region comprehensive framework study. Pac. Northwest River Basins Comm.

This appendix is one of a series making up a complete study on water and related lands in the Columbia-North Pacific Region. A history of fish and wildlife is followed by a regional summary of all fish and wildlife, their status and future needs, means to satisfy demand, needed research, legislation, and policy changes.

KEYWORDS: Fishing, management, harvest statistics, resource use, research needs, economics, legislation, administration.

267. Fish and Wildlife Technical Committee
1970. Appendix XI. Fish and wildlife. 239 p., illus. *In* Comprehensive study of water and related land resources, Puget Sound and adjacent waters, State of Washington. Pac. Northwest River Basins Comm.

One of 15 appendices providing supporting data for an overall water resource study, this appendix describes the uses of the Puget Sound Area by fish and wildlife, defines the locations of greatest importance and overall utilization, and presents a plan to conserve and enhance fish and wildlife short- and long-range needs. Information specific to human aspects of fish and wildlife management is included in the following areas of discussion: the present status and future needs of sport salmon fishing, game fish in streams, sport marine fish angling, sport shellfish harvest, means to satisfy the needs of salmon, marine, and shellfish through fisherman access development, and the present status and future needs of wildlife (big game, upland game, fur animals, waterfowl, and other wildlife).

KEYWORDS: Fishing, Washington, economics, management, harvest statistics, upland game birds, waterfowl, big game, characteristics, access, non-consumptive use, surveys.

268. Fish, Frederic F.
1967. Sport fishery statistics from the inland waters of North Carolina. 20th Conf. Southeast. Assoc. Game Fish Comm. Proc. 20: 404-408.

Data were obtained from 28,454 interviews conducted during routine license and creel checks between April 1964 and March 1965. Data show that only 53 percent of the anglers contacted were licensed. Of those who had licenses, 32 percent used cane poles, 49 percent used casting rods, 9 percent used fly rods, and 63 percent used natural bait. Of the unlicensed anglers, 64 percent used cane poles, 26 percent utilized casting rods, 4 percent had fly poles, and 98 percent used natural bait. Harvested fish are listed along with an explanation of license categories.

KEYWORDS: North Carolina, fishing, preferences.

269. Fobes, Charles B.
1945. Weather and the kill of white-tailed deer in Maine. J. Wildl. Manage. 9(1): 76-78, illus.

There are four major factors which determine the number of deer killed legally during a hunting season: deer population, hunter pressure, length of season, and hunting conditions. Hunting conditions constitute the most important factor and are regulated by the weather elements. As precipitation and rainy days increase, the deer kill also increases due to a quiet, moist forest floor. Light snow and the clearing after a heavy rain also favor hunter success.

KEYWORDS: Harvest statistics, Maine, big game.

270. Foley, Donald D.

1955. Certain aspects of waterfowl hunting in New York as indicated by bag-check data for 1953 and 1954. N.Y. Fish Game J. 2(2): 205-219, illus.

In 1953, 1,585 hunters on New York State shooting areas bagged 2,012 birds; in 1954, 2,929 hunters bagged 2,944 birds. Statewide, the black duck was the single most important species in terms of the number bagged. Hunting success averaged one bird bagged per 4 or 5 gun-hours. The use of dogs increased hunting success, as did the use of blinds. Hunting success on Long Island was increased substantially due to a later open season.

KEYWORDS: Waterfowl, New York, harvest statistics.

271. Folkman, William S.

1963. Levels and sources of forest fire prevention knowledge of California hunters. USDA For. Serv. Res. Pap. PSW-11, 22 p., illus. Pac. Southwest For. & Range Exp. Stn., Berkeley, Calif.

Data were obtained from 31 percent (3,060) of the mail questionnaires to 10,542 licensed hunters. Males 30-35 years of age from the smaller urban centers (under 25,000 population) make up the bulk of the California hunter population. They are mainly from the skilled, semiskilled, and professional-managerial occupations. Their level of knowledge about forest fire prevention averaged 78.9 percent correct for two 16-question tests. Knowledge was weak on California land ownership, the time of day when fires spread most rapidly, and legal implications of negligence. Most frequently reported sources of information about fire prevention are Forest Rangers, signs, and Smokey Bear. One hunter in five incorrectly listed lightning as the primary cause of fires. Conclusion is that California hunters know quite a lot about fire prevention. (Questionable results due to very low (21 percent) return. Questionnaire and five references are included. Also see Folkman 1965 and Christiansen 1969.)

KEYWORDS: Education, fire, California, safety, characteristics.

272. ________

1965. Residents of Butte County, California: their knowledge and attitudes regarding forest fire prevention. USDA For. Serv. Res. Pap. PSW-25, 32 p., illus. Pac. Southwest For. & Range Exp. Stn., Berkeley, Calif.

An interview survey of 761 respondents out of 851 contacted established fire prevention knowledge and attitude levels of Butte County residents and related these levels to the degree of exposure to high fire risk forest environment and to the socioeconomic characteristics of the sample. Solitary, back-country hunters who do not stay in campgrounds where fire hazards are low, who are farther from water than fishermen, and who hunt in the most hazardous season of the year are significant fire risks in spite of their comparatively high knowledge of safe fire use. Fishing and hunting were ranked fourth and fifth in number of participants in a list of eight recreational activities. Study is oriented toward forest users in general. (Questionnaire and nine references are included. Also see Folkman 1963 and Christiansen 1969.)

KEYWORDS: Fire, characteristics, education, California, safety.

273. Foote, Leonard E.
1945. Vermont's wild game resource: non-resident income. J. Wildl. Manage. 9(1): 81-82.

Almost $160,000 is spent in Vermont annually by non-resident hunters, with 80 percent going to private business and the remainder to the Fish and Game Service. Post-card questionnaires were sent to 1,800 of the 2,269 non-resident hunters purchasing licenses in 1943 in four Vermont counties. Results are based upon a 38-percent return. The average non-resident spent $5.01 per day, hunted 8.6 days a season, and traveled 140 miles by car in Vermont at a cost of $7.59. The deer herd brings in $80,000. Each deer killed by a nonresident was valued at $227, and each unit of small game was worth $6.50.

KEYWORDS: Economics, resident vs. nonresident, Vermont.

274. __________
1961. Southeastern State water legislation in relation to fish and wildlife. 15th Conf. Southeast. Assoc. Game Fish Comm. Proc. 15: 401-410.

KEYWORDS: Management, legislation.

275. Foran, A. E.
1934. A model uniform State game and fish law. 26th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 26: 97-104.

KEYWORDS: Landowner-private, legislation, management.

276. Forester, Richard T.
1971. Landowner utilization of a wild pheasant resource. Calif. Fish Game 57(4): 298-306, illus.

Of 340 property owners in the study area, 221 were interviewed to determine the utilization and economic importance of the wild ringneck pheasant resource in Stanislaus County, California. Only 7 percent of the landowners leased their lands for pheasant hunting. Over 1,600 hunters were given permission to hunt on unleased lands without fee, and 219 hunters paid for their hunting on leased lands. Compensation received by landowners for hunting rights was $9,905. Hunter success ranged from 6.6 birds per hunter per year on leased lands to 2.8 birds per hunter on unleased lands.

KEYWORDS: Characteristics, upland game birds, California, user fee.

277. Forrest, Nathan K.
1968. Effects of commercialized deer hunting arrangements on ranch organization, management, costs, and income--the Llano Basin of Texas. M.S. thesis, Tex. A&M Univ., 135 p.

In 1964, $246,001 of a total $3,452,051 for all farm and ranch products sold in Llano County was derived from commercial hunting, fishing, and other recreational services. Two groups of personal interviews with 86 ranchmen covered livestock production, deer herd management practices, deer leasing systems used, investments, expenses, and returns involved in the deer enterprise. Budget and investment data for domestic livestock on four ranches of 1,000 to 4,900 acres in size were developed. Gross income per acre from lease deer hunting enterprise on the four representative ranches was $0.89, $0.61, $0.86, and $0.99, respectively. Cash costs and non-cash

costs per acre for leases averaged about $0.05 per acre for each category. Representative net ranch income ranged from $1,819 on the 1,000-acre ranch to $8,311 on the 4,900-acre ranch. Returns to capital and management figured as a percentage of total investment ranged from 0.099 to 0.815 percent on ranches with leases. Four leasing methods were used: season leasing, day hunting, season leasing with a doe hunting option, and a combination of season and day hunting. The total costs of operating these hunting arrangements varied from $0.09 per acre for season leasing to $0.33 per acre for day hunting. Labor requirements for the deer enterprise averaged 12 times higher when managed by day hunting compared with season leasing. The expenses of the season lease with doe hunting option and season and day lease combination ranged from $0.19 to $0.27 per acre. Deer enterprise net income varied from $0.52 per acre on a 1,700-acre ranch managed under a season lease arrangement to $1.66 per acre on a 1,000-acre ranch which was day hunted. On a 2,850-acre ranch the season lease with doe hunting option and the season and day lease combination arrangements had the highest net returns at $1.12 per acre. Compared with the recommended harvest rate of 35 percent, the average percentage of the deer herd harvested ranged from 16 to 57 percent. While the larger ranches were able to spread overhead costs over more factors of production and were more efficient, the smaller ranches had the highest returns per acre due to surplus labor. Day hunting was the most flexible system and has the potential for maximum returns. It demands more labor and investment than the other hunting arrangements. Season leases are best suited to large ranches with limited labor. (Bibliography, 25.)

KEYWORDS: Texas, economics, big game, management, lease, user fee.

278. Fortney, Charles T., Robert M. Dimit, Donald R. Field, and Howard M. Sauer
1972. Attitudes of South Dakota farm operators toward wetlands and waterfowl production. S.D. State Univ. Agric. Exp. Stn. Bull. 592, 11 p.

Of 292 farmers interviewed, those with over 10 or less than 5 percent of their lands in wetlands had more favorable attitudes toward waterfowl production programs, as did those who hunted ducks or geese. Variables of tenure status, type of farming operations, property in native hay or pasture, property under cultivation, and reference group influences were not related toward waterfowl production attitudes.

KEYWORDS: Waterfowl, farmer-sportsman relations, preferences.

279. Fosburgh, P. W.
1953. Problems in free public hunting. N.Y. State Conserv. 7(4): 2-4.

Four interrelated problems are discussed: the means of encouraging biologically sound game management, protection of the interests and rights of landowners, the promotion of safety in hunting, and the means of improving the conduct of sportsmen afield.

KEYWORDS: Management, landowner-private, safety, education.

280. Frey, David G., Hubert Pedracine, and Lawrence Vike
1939. Results of a summer creel census of Lakes Waubesa and Kegonsa, Wisconsin. J. Wildl. Manage. 3(3): 243-254, illus.

A 1938 report on fishing data from two glacial, eutrophic lakes includes discussion of seasonal fishing trends, quality, success by species, pounds removed, fisherman number and hours, a comparison with records from previous years, and stocking records.

KEYWORDS: Fishing, harvest statistics, Wisconsin.

281. Friley, Charles E., Jr.

1954. Daily patterns of pheasant hunting pressure. J. Wildl. Manage. 18(2): 255-259, illus.

Report cards, required permits, and station checks at Michigan's Rose Lake Wildlife Experiment Station yielded the following. A shortened hunting day, particularly Saturday or Sunday, caused a high concentration of gun pressure within the first 2 hours, which increased hunter congestion and farmer grievances. Whether the opening-hour shift aids game conservation has not been determined, but preliminary analysis of other data showed no reduction in total opening day kill and no reduced hunting pressure.

KEYWORDS: Crowding, farmer-sportsman relations, Michigan.

282. Frye, Thos D.

1952. How can wildlife management keep pace with modern trends? 42d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 42: 57-64.

This subjective discussion on organizational and management practices and principles defines protectionists, annihilationists, and conservationists, and discusses administrative considerations to keep pace with modern trends. Examples are: build an organizational structure with present-day business efficiency, clearly define authority and responsibility between administrator and commissioners, select equipment and personnel to meet new trends.

KEYWORDS: Profession, education, management, administration.

283. Furst, S. Dale, Jr.

1947. Outlook in wildlife law enforcement. 37th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 37: 46-51.

In a law enforcement questionnaire study conducted by the Pennsylvania Game Commission, replies were received from 40 States, the U.S. Fish and Wildlife Service, and six Provinces in Canada. Statistics are based on a comparison of a 2-year period with the previous 2-year period. The total increase in penalties between the biennia was from $1,455,440 to $2,433,293 in the 40 States and from $62,117 to $115,134 in Canada. Factors contributing to increased violations include postwar psychology, an increase in the number of sportsmen, better economic conditions, and the high cost of living. There is approximately a two-to-one feeling that the problem is being solved. Stricter enforcement, increased personnel, public education, better equipment, and increased fines are suggested. Violations of game and fish laws are a comparatively new kind of crime, and public education and sensible legislation are essential to establishing the criminal aspects of game and fish law violations in the public mind.

KEYWORDS: Enforcement, surveys.

G

284. Gabrielson, I. N., John C. Huntington, John H. Baker, and I. T. Quinn
1938. The hows and whys of annual waterfowl shooting regulations. 3d Conf. North Am. Wildl. Trans. 3: 217-240.

A panel discusses the seemingly harsh waterfowl shooting restrictions in effect in the middle and late thirties, including suggestions for the development of a more satisfactory system of regulations. The four speakers represent the U.S. Biological Survey, More Game Birds in America, the National Audubon Society, and the Alabama Conservation Commission.

KEYWORDS: Waterfowl, management.

285. Gabrielson, Ira N.
1946. Trends in hunting and fishing. 36th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 36: 151-156.

The obvious trend is increased hunting and fishing pressure which was underestimated during World War II. A decline in public standards has increased bird-crippling. Administrators should discourage meat and pot hunters, provide more recreation per unit of game, increase the production of existing environment, and inform the public of limitations on the productive capacity of fish and game in each State.

KEYWORDS: Fishing, management.

286. ________
1948. What is wrong with wildlife administration? Wis. Conserv. Bull. 13(12): 3-7.

Sportsmen's groups are encouraged to eliminate some of the chief defects in current State game administrations by insisting that: the State conservation department be free from partisan and personal political interference, that it have adequate authority, that it resist uninformed pressures from hunting and fishing groups, that it have an adequate law enforcement staff, trained researchers, and adequate personnel to inventory game, that it have a sound education program, and that it devote its funds to produce more fish and wildlife.

KEYWORDS: Administration, conservation, clubs, historical value.

287. ________
1951. Wildlife management. 274 p., illus. New York: MacMillan Co.

Chapter 11, titled "Sportsmanship," gives a brief history of the decline of sportsmanship, what needs to be done now, and eight elements of goal sportsmanship.

KEYWORDS: Management, philosophy.

288. ________
1956. Sound wildlife administration. 10th Conf. Southeast Assoc. Game Fish Comm. Proc. 10: 2-6.

Four basic essentials for good wildlife management are adequate financing, adequate authority, and continuity of personnel and of programs. The role and function of the commission form of administration are discussed.

KEYWORDS: Administration, management, license fee, historical value.

289. _________
1959. Wildlife conservation. (2d ed.) 244 p., illus. New York: The MacMillan Co.

Of particular interest is chapter 13 titled, "Nongame Birds and Mammals." Non-game animals affect human interest according to whether they have a real or imaginary effect. Species that are "valuable" are divided into those that have economic use and those that have esthetic appeal.

KEYWORDS: Non-consumptive use, economics.

290. _________
1965. Review of current international trends in fish and wildlife affairs. 55th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 55: 72-77.

Examples of wildlife development on many continents indicate international concern. Programs in Africa, North America, and Mexico; the World Wildlife Fund; the International Whaling Commission; and the prospects for an international environmental conference under the United Nations are discussed.

KEYWORDS: Mexico, conservation, Africa, administration, education.

291. Gale, Larry R.
1954. The effects of season changes on hunting effort and game kill. 8th Conf. Southeast. Assoc. Game Fish Comm. Proc. 8: 117-120.

An annual kill survey revealed that a contraction of 12 days in the squirrel season did not result in less participation, fewer hunts, or smaller average season kill. Both hunting and season kill were closely related to squirrel population levels and weather. Similarly, increasing the rabbit and quail seasons by 8 days did not affect hunting effort or kill. The percentage of participating hunters, the average number of hunts, and average kill all rose coincidentally with a 34-day extension of the grouse season.

KEYWORDS: Management, small game, upland game birds, harvest statistics, Kentucky.

292. Gallizolli, Steve
1961. 10 year survey reveals some enlightening facts about hunters versus quail. Tex. Game Fish. 19(3): 9-11, illus.

Increasingly liberal quail hunting regulations stem from research which shows that legal hunting is not a factor in determining quail population levels.

KEYWORDS: Upland game birds, Arizona, management.

293. Gamble, Hays B., and Ronald A. Bartoo
1963. Economic returns from timber and wildlife on northeastern farmlands. J. Wildl. Manage. 27(3): 457-466.

A study of 18 Pennsylvania farms in Sullivan County in 1961 indicated net annual timber returns of \$330 per farm. This figure compares with annual returns of \$257 per farm for rooming and boarding hunters, \$42 for leasing hunting rights, and \$26 for fee hunting. Timber annually returned a gross of \$5.24 per acre, while deer annually averaged 95 cents per acre.

Total returns to the county for all wildlife were one-quarter that of timber. While deer and hunter damage cost $200 per farm year, hunter expenditures in surrounding communities amounted to about $546 per farm. Sullivan County landowners have little economic justification for habitat improvement or offering hunting opportunity.

KEYWORDS: Landowner-private, economics, Pennsylvania, benefits.

294. Garrett, J. R., G. J. Pon, and D. J. Arosteguy
1970. Economics of big game resource use in Nevada. Univ. Nev. Max C. Fleischmann Coll. Agric. Bull. 25, 22 p., illus.

The demand for hunting, the value of the habitat in improving hunting, and how to use this value in evaluating select range improvement activities for livestock and deer are estimated. Equations for demand and regression are given, based upon hunter expenditure per trip. A consumer surplus model indicates an estimated total value for the State of $1,037,876, and a value ranging from $24,107 to $155,042 among the eight areas studied.

KEYWORDS: Big game, economics, management, Nevada, resource use, benefits.

295. Garrett, James R.
1970. Characteristics of Nevada hunters. Univ. Nev. Agric. Exp. Stn. Bull. 22, 66 p., illus.

Questionnaires were sent to a 6.25-percent sample of all 1967 licensed resident and non-resident hunters. Following the 1968 season, another questionnaire was sent to approximately 2.5 percent of the registered hunters and all resident hunters of antelope, bighorn sheep, and elk. Each questionnaire included one followup. On the average, a Nevada resident hunter is a married male, 30-40 years old, has two children, is a skilled worker, has a high school education, earns $9,699 per year, hunts with three other persons, has hunted in the central Nevada management area for 6 years, has lived in Nevada for 11 years, and has a total of 16 years of hunting experience. He spent about 20 hours or 3 days hunting in 1967, and 57 percent of the hunters did not bag a deer. The average non-resident Nevada hunter is from northern California, resembles resident hunters in most ways but is over 50, self-employed, spends 4.8 days hunting, and usually hunts in a party of five. Resident hunters spent about $81.33 each compared with $265.25 for the non-resident. The number of deer thought to be in an area and previously hunted areas were primary attractions. Slightly over half the residents but fewer nonresidents expressed dissatisfaction with the abundance of deer. All hunters were satisfied with deer size, the number of hunters encountered, accessability, and terrain. The majority of hunters did not prefer a developed campground. (Arrangement and presentation of data require reader's discretion.)

KEYWORDS: Nevada, characteristics, preferences, economics, resident vs. nonresident, California.

296. Gartner, F. Robert, and Keith E. Severson
1972. Fee hunting in western South Dakota. J. Range Manage. 25(3): 234-237.

Experiments from 1966 to 1970 on a 100-square-mile area suggest that landowners who defer hunting on their land for a couple of years to build up trophy deer might realize substantial income. Up to $45 per hunter-day could be charged for guide service, food, and lodging. Theoretically,

$3,600 could be realized from 10 hunters for 8 days. Hunting of this type provides income and new social contacts for ranchers, cuts livestock losses, and promotes better range management. One problem of managing for trophy deer is the imbalance in deer herd sex ratio caused by harvesting trophy bucks but not removing surplus females.

KEYWORDS: Economics, South Dakota, landowner-private, guide.

297. Geis, Aelred D.
1963. Role of hunting regulations in migratory bird management. 28th Conf. North Am. Wildl. Nat. Resour. Trans. 28: 164-172, illus.

Review of available information suggests that the phenomena which cause hunting regulations to have little effect on the status of resident game species do not apply to migratory game birds. Hunting regulations influence the proportion of migratory game bird populations that are harvested, which in turn influences annual mortality rates. Furthermore, there is little evidence to suggest that increased hunting mortality is compensated for by either a reduction in non-hunting mortality or increased production. This emphasizes the important role of hunting regulations in migratory bird management.

KEYWORDS: Waterfowl, management.

298. George, Robert Worth
1966. A comparative analysis of conservation attitudes in situations where conservation education is a part of the educational experience. Ph.D. diss., Mich. State Univ., 153 p.

A total of 1,618 persons, including high school and college students and adults, were asked 64 questions to assess their conservation attitudes. Significant differences in conservation attitudes appeared between groups. High school students had the lowest total score and adults, the highest. Age and education were associated with the most significant differences in attitudes of high school students; age and sex were associated with the college student group; and sex and residence with adults. Extracurricular activities with a conservation theme influenced attitudes the greatest. Attitudes toward conservation do change with interest in and exposure to conservation knowledge. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Conservation, preferences.

299. Gerstell, Richard
1938. Measured game and recreational production on controlled shooting areas. 3d Conf. North Am. Wildl. Trans. 3: 570-575.

Methods of establishment and operation are given for 2-year permit system of hunting pheasants, grouse, rabbits, and squirrels. Cost of establishment was $250, with $335 annual operating expense. Operating statistics given for three Pennsylvania areas during 1936-37 show an average of 4.2 hunting hours per man. In one area it took an average of 11 hours hunting per bird killed, and in another area it took an average of 3.3 hours per rabbit killed. (References, 3.)

KEYWORDS: Harvest statistics, economics, management, Pennsylvania.

300. Gilbert, Bil
1967. Hunting is a dirty business. Sat. Evening Post, Oct. 21. Reprinted in Wild Cascades, Feb.-Mar. 1969, p. 16-17.

The sports-hunting establishment is the most pampered, privileged, subsidized recreation group in existence. Sports hunters are characterized as enlightened conservationists whose fees and political support make possible wildlife research, protection, and preservation. The truth is that about half of the State game funds are spent to hire wardens to protect wildlife from gunners. About 25,000 public State and Federal "conservation" workers cost nearly $500 million a year to make it easier and quicker for gunners. The annual refuge budget is about $30 million, and the annual income from duck stamps is only $5 million. Hunters are minority users of wildlife; and although their numbers are declining, they still grab more privileges. One solution is to allocate wildlife agency funds from general State revenues. The increase in numbers of non-hunting wildlife users suggests a source of conservation funds that might more than compensate for the loss of hunters' fees.

KEYWORDS: Economics, management, antihunting.

301. Gilbert, Douglas L.
1951. Economics and related biology of the black bear in Colorado. M.S. thesis, Colo. Agric. Mech. Coll. (Colo. State Univ.), 164 p.

Two-year study on 118-million-acre area in Southwest Colorado assessed the controversy between stockmen and sportsmen. Of 11 reported livestock losses to bears, only three were valid, five questionable, and three definitely due to other causes. Letters sent to 60 game departments in United States, Canada, Alaska, and Mexico revealed that hunting license fees ranged from $1.50 to $7.50 for residents, $10 to $50 for nonresidents, and bounties ranged from $3 to $15. Questionnaires sent to 250 people including stockmen yielded a 25-percent return and indicated that 97 percent and 79 percent, respectively, had never known of bears killing cattle or sheep. Extensive data were given on bears' biology, life history, and description. Author recommends treating the bear as a game animal with protection for recreational uses but suggests continuing control where livestock values are high and bear damage is imminent. (Excellent literature review and descriptive life history information about black bear. Literature cited, 139.)

KEYWORDS: License fee, Colorado, harvest statistics, predator, big game.

302. ________
1956. Television as a wildlife-education medium. J. Wildl. Manage. 20(4): 456-458.

A wildlife conservation education TV program, its problems, operation, and programing are described.

KEYWORDS: Education, communications, Colorado.

303. Gilbert, Douglas Lee
1963. Public relations and communications in wildlife management. Ph.D. diss., Univ. Mich., 209 p.

Principles of good public relations pioneered in big business and government have been delineated and presented with wildlife management examples. A questionnaire to 50 State conservation departments provides data. Presented are suggestions and techniques to aid the wildlife management agency in selecting and training public relations personnel and in using various communications media as methods of contact. Few State conservation agencies have public relations departments, and their information

and education departments are grossly understaffed and undersalaried. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Public relations, education, management, surveys, communications.

304. Giles, Robert H.
1969. A strategy for resolving a wildlifer's dilemma. Wildl. Soc. News 123: 33.

Public officials are responsible for presenting several "best" alternatives to the public for their decision, but there is conflict between participatory democracy and expertise in decisionmaking. Wildlifers have been deciding game population goals that are the prerogative of citizens to establish and have irresponsibly presented "right" answers instead of alternatives with advantages, risks, and costs. They assume maximum faunal productivity is their management goal. They need to clarify wildlife management objectives in terms of human benefits and better interpret political, social, economic, and human values and ecological concepts. Wildlifer's role needs clarification in relation to the commission he serves, and the actual decision risks should be left to wildlife commissioners. (A rebuttal "Sincerely Yours" by Malcolm G. Edwards is in *The Wildlife Society News*, No. 126, Feb. 1970.)

KEYWORDS: Administration, public relations, profession.

305. Giles, Robert H., Jr., and Robert F. Scott
1969. A systems approach to refuge management. 34th Conf. North Am. Wildl. Nat. Resour. Trans. 34: 103-115, illus.

The systems approach is a style of thought and action that treats animals, organizations, ideas, problems, land, and resources as systems. Adopting and implementing it in the National Wildlife Refuge System, its foundations, its advantages and limitations, and its broad implications and future directions are discussed.

KEYWORDS: Refuge, management.

306. Gillham, Charles Edward
1946. The goose and the golden egg. 11th Conf. North Am. Wildl. Trans. 11: 478-486.

By citing examples of their contributions to safety, education, conservation, and research and the economic values derived from supplying guns and ammunition and by discussing who hunts, what the hunter shoots, and how much he kills, the arms and ammunition manufacturers make it evident that they do not wish to see the "recreation goose" threatened. Accordingly, all types of shooting should be forever perpetuated, people should have a place to hunt regardless of the bag limit, and much of the desire to shoot should be satisfied by trap and skeet shooting.

KEYWORDS: Economics.

307. Gilligan, James P.
1954. Wildlife values in western wilderness area management. J. Wildl. Manage. 18(4): 425-432.

A review of the initial purpose, development policies, and present status of the western wilderness areas includes a discussion of harvesting problems on wilderness areas, the conflict between wilderness retention and

game population, and examples of helicopter landing sites, cabins, fencing, corrals, grazing, commercial timberland, dams, and other developments which have changed the authenticity of the original wilderness area idea. Primitive methods of game harvest can be encouraged by reducing non-resident license fees and by providing special-rate transportation or extra game bonuses.

KEYWORDS: Management, conservation.

308. Glading, Ben
1968. The role of private hunting clubs in California. 48th Conf. West. Assoc. State Game Fish Comm. Proc. 48: 129-141.

Population pressure, urbanization, and the abundance of good pheasant and deer habitat on private lands have contributed to the increase of California private clubs and hunting preserves. The development of these clubs is traced. Clubs vary considerably in management: for a lucrative hobby, a large scale enterprise, a 100-percent pheasant hunting operation, a multiple use recreation area, or a means of ending severe erosion caused by wild goats.

KEYWORDS: Big game, California, upland game birds, economics, historical value, clubs.

309. Glassen, Harold W.
1952. Do States still own their game and fish? 42d Conf. Int. Assoc. Game Fish Conserv Comm. Proc. 42: 32-38.

KEYWORDS: Legislation, Michigan, enforcement, historical value, Federal-State jurisdiction.

310. Goddard, Stephen V.
1962. Factors affecting the waterfowl hunter utilization and the waterfowl kill at the Bear River Migratory Bird Refuge, 1960-1961. M.S. thesis, Utah State Univ., 107 p., illus.

Interviews were taken from 1,266 Utah hunters over 2 years. The following information was gathered: home county of hunter, his age and sex, where he hunted on the refuge, type of concealment used, transportation used and miles driven, hunter success, times hunted both in and out of the refuge, hunter use of retriever and decoys, why the refuge was chosen for hunting, years hunter had hunted the refuge, why he chose the concealment he used, and whether other areas of the refuge would be hunted if access were available. Field observations determined hunter distribution and types of concealment used by hunters. (Interview schedule is included, along with 36 reference sources.)

KEYWORDS: Utah, waterfowl, preferences, crowding, characteristics.

311. Goldman, E. A.
1927. What to do with the Yellowstone elk? Am. For. For. Life. 33: 279-282, illus.

The remarkable comeback of the Yellowstone elk and the alternatives for managing future increases are discussed.

KEYWORDS: Big game, historical value, management, Wyoming.

312. Goodson, Brantley
1968. Some general aspects of human motivation. 22d Southeast. Assoc. Game Fish. Comm. Proc. 22: 538-541.

A law enforcement officer's interest, attitude, and performance depend to a large estent on motivation. Suggestions for motivating officers are included.

KEYWORDS: Enforcement, profession.

313. Gordinier, Earl J.
1957. Yield and public use of Michigan State game areas. 22d Conf. North Am. Wildl. Trans. 22: 404-412, illus.

Data obtained through hunter car counts, a post-card poll, and field surveys yielded the following. Hunting pressure on upland areas averaged at least three times the pressure on private farmland, checking stations on two waterfowl areas indicated an average daily hunter pressure nearly 14 times that of the upland areas, and hunting pressure was heavier on unlimited areas than on controlled areas. Non-hunting recreational uses included camping, fishing, picnicking, and swimming. The cost of the program during 1955-56 averaged $2.85 per acre. Advantages of the game area program are: they support 6-1/2 percent of the total hunting effort in southern Michigan, they offer 1 to 2 million hours of non-hunting recreation annually, they use previously useless lands, and they demonstrate applied conservation and serve as game management laboratories.

KEYWORDS: Crowding, non-consumptive use, Michigan, harvest statistics.

314. Gordon, C. Douglas, D. W. Chapman, and T. C. Bjornn
1969. The preferences, opinions, and behavior of Idaho anglers as related to quality in salmonid fisheries. 49th Conf. West. Assoc. State Game Fish Comm. Proc. 49: 98-114, illus.

Each of six Idaho fishing license classes was sampled by mail questionnaire of 10,000 anglers. After one followup reminded, returns were estimated at 50 percent. A telephone interview with 143 nonrespondents disclosed no significant differences between respondents and nonrespondents. Anglers had strong and specific preferences, opinions, and behavior patterns that were significantly influenced by age and income. For example, as age increases, preference shifts from mountain lakes to salmonid fishing in lowland lakes. These relationships should be monitored to provide suitable angling opportunities for all socioeconomic groups. Many anglers are willing to pay more to maintain or improve specific fisheries. A reduction of bag limits is preferred over restrictions on seasons or other regulations. Most anglers preferred to catch a few medium-sized fish rather than many small ones or one large one.

KEYWORDS: Fishing, user fee, Idaho, characteristics, preferences.

315. Gordon, Seth
1930. Giving the game policy the laboratory test. 17th Conf. Am. Game Trans. 17: 7-24.

The American Game Policy proposed in 1929 resulted in two points of agreement; first, sportsmen must pay for their shooting or go without, and second, unless the landowner is given a square deal and a workable partnership with sportsmen he will be more rebellious, allow no hunting and ignore

the game crop. This paper reports on a plan to conduct a 19,000-acre laboratory test in Michigan to determine what can be done to produce and harvest a farm game crop without hinderance to the farm operation.

KEYWORDS: Farmer-sportsman relations, license fee, administration, plant and shoot, Michigan, historical value.

316. ________
1956. California's pheasant tag system. Wis. Conserv. Bull. 21(8): 11-12.

A California hunter pays from $1 to $10 for pheasant tags. This plan aids law enforcement and sportsmanship and insures that those who benefit from the program contribute funds to support it.

KEYWORDS: California, upland game birds, user fee.

317. Gordon, Seth, Jr.
1940. A sampling technique for the determination of hunters' activities and economics thereof. M.S. thesis., Univ. Mich.

Restricted to University of Michigan campus use. (See Gordon 1941.)

KEYWORDS: Characteristics, economics, research methods, Michigan, harvest statistics.

318. ________
1941. A sampling technique for the determination of hunters' activities and the economics thereof. J. Wildl. Manage. 5(3): 260-278, illus.

A 1939 Michigan interview of 300 licensed and non-licensed hunters revealed that the order of questions was related to the correctness of the responses. Resident hunters in one county expended almost $66,000 in the 1938 season, invested $20,000 in guns, and trapped furs valued at $15,000. Half of the hunters interviewed had incomes less than $500. During 94,000 hunter hours, 3,900 pheasants and 14,000 rabbits were bagged.

KEYWORDS: Economics, harvest statistics, characteristics, Michigan, research methods.

319. Gordon, Seth E.
1931. The dog, the deer and the buck law. 23d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 23: 77-81.

The history behind the law prohibiting the hunting of deer with dogs is discussed.

KEYWORDS: Big game, Pennsylvania, historical value, legislation.

320. Gottschalk, John S.
1966. The 1965 national survey of fishing and hunting. 56th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 56: 154-158.

Brief summary is given of the Bureau of Sport Fisheries and Wildlife 1965 National Survey of Fishing and Hunting.

KEYWORDS: Surveys, fishing, economics.

321. ________
1972. The German hunting system, West Germany, 1968. J. Wildl. Manage. 36(1): 110-118, illus.

Germany's extensive game populations are intensively managed by limiting hunting to less than 0.1 percent of the population. Game research is extensive and supported by hunting clubs. A comparison is made between management techniques of 1935 and 1968. Approximately 84 percent of West Germany is usable for hunting, but hunting rights may cost as much as $5,000 per year. Hunters are preoccupied with the trophy aspects of hunting, because seasons are long and there are no bag limits.

KEYWORDS: Germany, clubs, preferences, resource use, management, historical value.

322. Graham, Charles T.
1964. Fee hunting in the State of Washington. 44th Conf. West. Assoc. State Game Fish Comm. Proc. 44: 103-105.

KEYWORDS: Washington, upland game birds, management.

323. Grahame, Arthur
1960a. Happy hunting? Outdoor Life 126(4): 66-68, 146-150, illus.

Various hunting programs are covered. Game-farm systems from Pennsylvania and New York and cooperative programs in Connecticut, Tennessee, Washington, Utah, and Arkansas are explained. It would be less costly in the long run to lease or arrange paid hunting on private land than to attempt large-scale acquisition of land for public hunting. Paid hunting could change the hunter from an unwelcome or tolerated intruder to a sought-after customer by farmers. An overall plan is needed which can be modified to fit varying conditions in the country.

KEYWORDS: Access, management, landowner-private, user fee.

324. __________
1960b. Paid hunting, threat or hope? Outdoor Life 126(2): 33-35, 86-90, illus.

The current trend shows increasing posted hunting lands and an increase in fee hunting. Eighty-five percent of all hunting is done on 1-1/2 billion privately owned acres. The day of free hunting is nearly over and the problem is not maintaining free hunting, but maintaining hunting within the financial reach of the average man.

KEYWORDS: User fee, management, access, landowner-private.

325. __________
1960c. Paid hunting is here, part 2. Outdoor Life 126(3): 62, 63, 116-120, 124, 125, illus.

The article outlines paid hunting systems in the United States: pay-as-you-shoot hunting on commercial shooting preserves, hunting on game preserves owned or leased by sportsmen, informal partnerships or organized non-commercial hunting clubs, hunting on land owned or leased by State game commissions which charge a fee in addition to the hunting license, hunting on land controlled by community organizations that charge fees and contribute profits to community or charitable causes, landowners charging sportsmen a right-of-way fee to gain access to free public land, landowners charging individual sportsmen a camouflaged hunting fee, and hunting on land for which the owner charges a direct fee.

KEYWORDS: Landowner-private, management, user fee, access.

326. ________
1963. No more free hunting? Outdoor Life 131(2): 14, 15, 102, 103, illus.

Increasing amounts of private land are being taken out of free hunting status and placed in the 'paid hunting' category. Public lands will follow this trend. Supply and demand will endanger paid hunting by driving the price above the limits of most hunters. What is needed is a guide for development of paid hunting.

KEYWORDS: Management, landowner-private, user fee, access.

327. Gramlich, Francis James
1965. A study of factors related to low deer harvests in a portion of eastern Maine. M.S. thesis, Univ. Maine, 106 p., illus.

Data on the variables of timber harvest, forest fire occurrence, accessibility, remoteness, forest cover types, hunting pressure, and hunters were related to deer harvest in southeast Maine using multiple regression to determine factors related to consistently low deer harvest. Data were collected by (1) random sample interview questionnaire of 347 individuals, and (2) ground and aircraft surveillance of hunter vehicles to provide an index of hunting pressure. Results show that remoteness (also reflecting lower pressure) and hunter-related factors are more important to low deer harvests than environmental factors. Remoteness (more than 1 mile from a road) accounted for at least 60 percent of the variation (.01 level of significance) in deer kill within the low-harvest area. Also, "The number of hunters and their length of stay in camp have no uniform effect on hunting pressure or deer harvest." Further, harvest was not linearly correlated with total human population of the area. Hunter opinions are almost unanimous that deer populations are lower now than in earlier years, but the opinions are evenly divided on whether or not hunting pressure has increased over the years. (Bibliography, over 60 entries.)

KEYWORDS: Big game, preferences, harvest statistics, characteristics, Maine.

328. Gray, James Madison
1964. Estimated annual consumer hunting expenditures for license purchasers in the coastal plain of Virginia, 1963-1964 hunting seasons. M.S. thesis, Va. Polytech. Inst., 65 p., illus.

Mail questionnaire study of 552 Virginia Coastal Plain hunters (0.4 percent of population) is stratified by big game, small game, and waterfowl license holders. A 51.8 percent return cost $.58 per mailed questionnaire. License holders listed before and after the randomly chosen hunters were contacted if nonresponse resulted from first contact. Thirty-five expense categories including equipment, food, transportation, and dogs showed a total projected expenditure of $34.6 million for the 1963-64 hunting season in Virginia. Transportation was the major expense for resident and nonresidents, while guns were largest expense for county residents. State residents proved to be youngest hunters while county hunters were oldest. (Primary concern is with sampling and methodological problems. Numerous tables in appendix.)

KEYWORDS: Economics, research methods, Virginia.

329. Green, Bernal L., and H. A. Wadsworth

1967. Boaters, fishermen, hunters--what affects participation and what do they want? Purdue Univ. Agric. Exp. Stn. Res. Bull. No. 829, 32 p., illus.

Four variables affect boating participation: participation increases with income and number of years that a boat has been owned but declines with increased days of paid vacation and increased distance traveled to boating areas. For fishing, people classed as clerical and craftsmen tend to make more short fishing trips than professionals, single persons take more short trips than married persons, and fewer long fishing trips are taken when wives are not employed or when distances traveled increase. Average one-way distance traveled was 19 miles on short trips and 284 miles on long trips. Three variables significantly affect participation in hunting: managers, craftsmen and operatives take fewer long hunting trips, while those in sales spend more days on long hunting trips than professionals; participation tends to decline with age; and those who took more short fishing trips also took more short hunting trips. Hunters averaged, one way, 19 miles on short hunting trips and 226 miles on long hunting trips. Data were obtained from questionnaires returned by 50 percent of 1,737 boat owners and 43 percent of the 18,000 fishermen-hunters contacted.

KEYWORDS: Non-consumptive use, fishing, characteristics, Indiana, economics, research methods.

330. Greenberg, Robert Edward

1964. An analysis of opposition to scientific management of Michigan's deer herd. M.S. thesis, Univ. Mich.

Restricted to University of Michigan campus use.

KEYWORDS: Management, big game, Michigan, preferences.

331. Greene, A. F. C.

1954. Does fisheries research pay dividends to the angler? 34th Conf. West. Assoc. State Game Fish Comm. Proc. 34: 55-60.

Deterrent to good management is the disparaging connotation of "research" and the hesitance of administrators to recognize the values of research findings. Research enables us to remove uncertainty and biased opinions, to assure greatest returns for money spent, and to liberalize regulations. Research makes more fishing available to the angler through studies of stocking, hatchery management, and reclamation projects. (This is a general plea for the acceptance of fisheries research and a general overview of its benefits.)

KEYWORDS: Management, fishing, research needs.

332. Greene, Jeffrey C.

1970. Characteristics of some Michigan shooting preserve users. J. Wildl. Manage. 34(4): 813-817.

Characteristics of 241 users of Michigan shooting preserves were determined by mail questionnaire. Most hunters visited preserves because of lack of game birds during the open season. Over half of the preserve hunters did not use preserve-owned hunting dogs. Two-thirds of the hunters lived in urban areas and they averaged 26 years of hunting experience. Compared with other hunters, preserve hunters were found to have higher incomes, more

formal education, and more professional/proprietor types of occupations. Users seemed satisfied with their hunting experiences.

KEYWORDS: Refuge, Michigan, characteristics.

333. Greenough, Tallent
1965. Should fish and game be used to attract the tourist industry. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 30-35.

KEYWORDS: Fishing, oregon, user fee, management, non-consumptive use.

334. Greenwood, Anthony
1949. Should blood sports go? Spectator 182(6291): 71,72.

According to this British article, hunting is morally indefensible as it is cruel to animals and degrading to participants; it is an inefficient, uneconomical way of controlling pests. Fox hunting is an expensive form of destruction and its cost is not borne entirely by those who can afford to hunt. The true cost of hunting is extreme because hunting land could otherwise be used for food production, property is damaged by hunters, and the slaughter of lambs and poultry by foxes preserved for hunting is great.

KEYWORDS: Economics, predator, antihunting, England.

335. Gregg, Frank
1955. What's wrong with State conservation magazines? 20th Conf. North Am. Wildl. Trans. 20: 616-624.

KEYWORDS: Literature, public relations, conservation.

336. Grieb, Jack R., and David C. Bowden
1966. Effects of pre-hunting season notification on hunter questionnaire data. 46th Conf. West. Assoc. State Game Fish Comm. Proc. 46: 233-238.

Half of 12,000 randomly sampled license buyers were contacted by explanatory letter before the survey and 50 percent were not. Of those receiving the letter 71 percent responded to the questionnaire. Data indicate that hunter reports of game bird and rabbit hunting activity, harvest, and location do not differ significantly between the two groups. Pre-survey contact has little or no effect on questionnaire answers, and it is therefore recommended that current hunting license stubs be used to determine hunting statistics for small game and waterfowl species.

KEYWORDS: Research methods, harvest statistics.

337. Gutermuth, C. R.
1949. Forest-wildlife ideologies. J. For. 47(11): 886-889.

Paper emphasizes the importance of "people management" in natural resource management, discusses Forest Service progress and failure, and suggests that public participation, appropriations, and management support can be obtained only if wildlife "sells" its program to the public.

KEYWORDS: Public relations, management.

338. Guthrie, W. Alan
1969. Game stocking, does subsidizing nature pay? Va. Wildl. 30(4): 10-11, illus.

KEYWORDS: Management, upland game birds, small game, historical value.

339. Guyant, Tom
1958. Unseen deer. Tex. Game Fish 16(4): 4.

Michigan's department of conservation placed a known number of deer within a 647-acre tract. From three to 10 hunters spend 18 days over a a 3-year period hunting them. The hunters consequently realized that deer--even thickly populated--are hard to get. During buck-only hunts, shooters saw one deer for every 0.9 of an hour and a buck each 10.2 hours. They saw 27 percent of the available deer but only 10 percent of the available bucks.

KEYWORDS: Management, Michigan, big game.

H

340\. Hamilton, Lawrence S., and E. T. Van Nierop
1965\. Should we fish and boat on our reservoirs? N.Y. State Conserv. 20(2): 12-14, illus.

Public health and economic and legal aspects of the multiple use of reservoirs are considered.

KEYWORDS: Resource use, New York, fishing, economics.

341\. Hamnett, W. L.
1961\. Hunter safety training as a part of I&E in North Carolina. 15th Conf. Southeast. Assoc. Game Fish Comm. Proc. 15: 432-434.

Growth of the State's hunter safety program is outlined. Conclusion is that the volunteer program is more effective among sportsmen than is the mandatory program.

KEYWORDS: North Carolina, safety, education.

342\. Handley, Rolland B., and Austin C. Shattles
1955\. The development of public hunting areas in Mississippi. 9th Conf. Southeast. Assoc. Game Fish Comm. Proc. 64-67.

In Mississippi, managed areas developed for controlled hunting total 397,000 acres, with another 500,000 acres available when funds permit. The Red Creek Wildlife Management Area is an outgrowth of a refuge. Fees are not paid for leasing the land: landowners provide land in exchange for protection of their interests. All State areas are being developed to provide wide utilization of resources by as many people as possible.

KEYWORDS: Mississippi, landowner-private, management.

343\. Handman, William
1961\. What the tourist division of the Georgia Department of Commerce is doing to promote hunting and fishing in Georgia. 15th Conf. Southeast. Assoc. Game Fish Comm. Proc. 15: 455-457.

Promotional devices include billboards, brochures, a travel exhibit, publicity releases, and a travel survey to determine the importance of hunting and fishing to Georgia's tourist industry.

KEYWORDS: Fishing, economics, Georgia, public relations.

344\. Hanlon, Robert William
1956\. An analysis of the bounty system in Minnesota and its impact on conservation education. M.S. thesis, Mankato State Teachers Coll., Minn. 61 p.

Bounty records dating back to 1943 and a questionnaire survey of all county auditors in Minnesota, North and South Dakota, Iowa, and Wisconsin were the basis of this study. All questionnaires were returned. Current literature reflects almost unanimous opposition to the use of the bounty system as a means of predator control, but Minnesota depends exclusively upon bounties for this purpose. By law, bounty payment is handled through the county auditor's office. Bounties paid in 1954 totaled $267,825.26. During this same period, Iowa paid $145,235.40, Wisconsin $91,260.50, and

South Dakota $134,638.50 in bounties. Bounties paid by species in Minnesota during 1954 were $5,885 for 171 wolves, $49,325 for 1,881 coyotes, $23,155 for 1,543 bobcats, $1,765 for 110 bear and $144,680 for 40,422 foxes. Fraud is possible because of different payment and marking systems by the various counties which make it possible for the same animal to be bountied more than once. Bounties on gophers, woodchucks, crows, and rattlesnakes in 1954 cost $34,009. An additional $8,000 was paid but complete records could not be obtained for tabulation. Author concluded that bounty payment system lacks any degree of control. (Impact of bounty system on conservation education (title) is almost nonexistent, but author presents several "conversations with students." Questionnaire included. Bibliography, 18.)

KEYWORDS: Minnesota, education, predator.

345. Hare, C. E.
1949. The language of field sports. 276 p., illus. New York: Charles Scribners Sons.

The author attempts to establish definitively the proper names and their modern descendents of sporting terms. Included are ancient and modern hunting terms, unusual terms, group terms, some Dutch terms, pet names, phrases and origins, a table of terms with several meanings, and a list of authorities of terms. Most of the terms are now considered obsolete by many authors.

KEYWORDS: Dictionary, library, historical value.

346. Harkness, William J. K.
1948. The legislative basis for improved fish and wildlife law enforcement. 38th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 38: 128-130.

Enforcement is an integral part of fish and wildlife management. Education of the public and the legislators is needed to obtain desirable legislation for good management.

KEYWORDS: Legislation, enforcement.

347. Harper, Harold T., Chester M. Hart, and Dale E. Shaffer
1951. Effects of hunting pressure and game farm stocking on pheasant populations in the Sacramento Valley, California, 1946-1949, Calif. Fish Game 37(2): 141-176, illus.

A 4-year pheasant hunting study was made on two areas in the Sacramento Valley from 1946 to 1949. Only one area was stocked. Hunter checks and airplane counts of hunters' cars provided data. A 10-day season limited to two cocks per day and 10 per season was operated during the study. In the first 3 days of hunting, 70-80 percent of the seasonal hunting pressure was exerted and 70 percent of the kill taken. Study results indicate that the planting of game farm hens has no lasting or cumulative effect in increasing pheasant production. Returns from transplanted wild birds were greater than from farm birds when both were liberated at comparable ages. Opening areas to hunting that have previously been closed will provide more birds for the hunter than any other single management method.

KEYWORDS: Harvest statistics, management, upland game birds, California, plant and shoot.

348. ________ Robert D. Mallette, John W. Speth, Roger L. Allemand, and Walton A. Smith

1965. A review of the licensed pheasant club program in California, 1939-1963. Dep. Fish Game, State Calif. Proj. W-47-R, 37 p., illus., 47 misc. p.

The licensed pheasant club program started with 17 clubs in 1940, and by 1964, 191 were licensed to include about 169,000 acres. Hunter use has increased from 30 man-days hunted per thousand acres in 1940 to 380 man-days in 1963. Due to hunter demands for easy-to-kill birds, need of operating funds, and Commission regulations, the hunter's kill shows a higher proportion of planted birds than wild birds. Approximately 40 percent of Zone A clubs (clubs having natural pheasant reproduction) practiced habitat management or manipulated lands for pheasants. Many of the Zone B licensed areas (having no natural pheasant reproduction) are devoted entirely to wildlife as a major source of revenue. The use of these clubs has grown phenomenally compared with general pheasant tag sales which have remained level.

KEYWORDS: California, clubs, upland game birds, historical value.

349. ________ George Metcalfe, and John F. Davis

1950. Upland game cooperative hunting areas. Calif. Fish Game 36(4): 404-432, illus.

To open land closed to pheasant hunting, Senate Bill No. 677 was passed by the State Legislature in 1949. Six cooperative areas were opened that year to a maximum of 7,500 hunters and provided 41,166 man-days of hunting with a kill of 12,114 birds. Returns from 7,797 stocked birds were 47 percent. About 63 percent of the hunter days and two-thirds of the total kill was made during the first 3 days of the season. The area which charged a fee had the highest average number of hours hunted per day, the highest success, and the lowest pressure. The area most convenient to hunters with limited time had the lowest average hours hunted. Hunter success was uniformly higher and crippling loss lower when dogs were used.

KEYWORDS: Upland game birds, harvest statistics, legislation, plant and shoot.

350. Harris, Peyton Randolph

1940. The Pisgah Deer Case, United States of America, plaintiff, against J. D. Chalk, and others, defendants. 34th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 34: 90-109.

The legal aspects of the Pisgah Deer Case are discussed: a suit between the United States and six officials of the State of North Carolina Division of Game and Inland Fisheries. The suit was filed by the United States when State Game and Fish Protectors confiscated deer which Federal wardens had trapped on the Pisgah Game Preserve and were in the process of transporting to points outside the State.

KEYWORDS: Management, North Carolina, big game, historical value, Federal-State jurisdiction.

351. ________

1944. Wildlife, the public interest and the law: an approach to the problem of public land management. 9th Conf. North Am. Wildl. Trans. 9: 96-105.

This is a discussion of Federal versus States' jurisdiction over

wildlife resources with respect to the National Forests. The issue of local self-government is raised through an historical consideration. Congress has thrice directed the Federal Government to aid in enforcement of the State laws on Federal forest lands. The Forest Service's disregard for State game and fish laws is caused by "lust for Federal power," the "property protection theory," and State statutes which gave consent for Federal land acquisition for the purpose of preserving stream navigability. The Forest Service has no right to destroy without compensation deer which damage the forests and belong to the people of the State. Legislation is needed to destroy with respect to National Forests "...the evils of bureaucratic control...the poison ivy which is choking the tree of liberty." New York State's preservation of local self-government of forests is applauded. Several references to laws, legal statutes, and the Constitution support the author's "states rights" opinion.

KEYWORDS: Management, New York, legislation, Federal-State jurisdiction.

352. Harrison, Jim
1971. Grim reapers of the land's bounty. Sports Illus. 35(15): 38-40, 43-44, 47-48, illus.

Hunters and anglers who do not heed fish and game codes and despoil nature are the subject of indictment. Most sportsmen follow the laws, but the majority is scarcely overwhelming. City dwellers seem to be most guilty of the "cowboy consciousness"--land is endless, unspoiled, mysterious, still remaining to be overcome and won. The jacklighters, fish snaggers, and law violators do not respect the spirit of the law and they would persist even if no game were left on earth. There are signs of change, such as judges becoming sterner and people becoming environmentally aware.

KEYWORDS: Antihunting, law violation.

353. Hart, Chester M.
1954. Pheasant hunting pressures in California. 34th Conf. West. Assoc. State Game Fish Comm. Proc. 34: 219-226, illus.

Pheasant hunters have doubled in California since prewar years, with tag sales reaching 215,000 in 1953. Another 50-percent increase by 1960 is anticipated. Habitat averages less than 10 acres per hunter. The Department's cooperative hunting program absorbs 10 percent of the total hunting pressure. Seasonal use averages 50 man-days per 100 acres. Bird harvest varies from 50 to 85 percent.

KEYWORDS: California, harvest statistics, upland game birds, historical value.

354. _________ John F. Davis, and Wilbur F. Myers
1952. Pheasant cooperative hunting area results, 1951. Calif. Fish Game 38(4): 597-604, illus.

Eleven cooperative hunting areas totaling 153,789 acres were operated by the Department of Fish and Game during the 1951 pheasant season. A total of 21,781 pheasants were taken on the areas in 54,701 man-days of hunting. Success was 0.40 bird bagged per hunter day. The total number of individual hunters using the areas was approximately 36,235, nearly 20 percent of the number of pheasant tag buyers. From 1949 to 1951 there have been increases of 113 percent in the total hunting acreage, 33 percent in hunter use and 62 percent in the number of pheasants bagged.

KEYWORDS: California, upland game birds, harvest statistics, plant and shoot.

355. ________ Fred L. Jones, and Dale E. Shaffer
1951. Pheasant cooperative hunting area results, 1950. Calif. Fish Game 37(4): 395-437, illus.

A total of 104,213 acres were opened for a 10-day season of controlled hunting with a maximum 8,770 hunters permitted at one time. A total of 47,889 man-days of hunting resulted in a kill of 17,523 birds. Half this total kill occurred during the season's first 3 days, and half the hunter days occurred during the opening week. Birds released in season gave a 70-percent hunter return, but those liberated a week prior to the season yielded a 65-percent return. Hunters with dogs experienced higher success and lower crippling.

KEYWORDS: California, upland game birds, harvest statistics, plant and shoot.

356. Hart, M. D.
1933. Tinkering with our game laws. 27th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 27: 130-132.

Constantly changing game laws confuse sportsmen and cause unintentional violations. Counties should be zoned and uniformly regulated.

KEYWORDS: Management.

357. Hatter, James
1965. Conservative implications of fishing derbies. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 232-233.

KEYWORDS: Canada, fishing, resource use.

358. Hatton, John H.
1929. Wild life administration. J. For. 27(2): 254-261.

An intelligent program of administration of wildlife is presented with two subdivisions: supervisory administration (responsibility for game protection) and resource administration (game as a recreational and productive resource). Conflicts in State and Federal jurisdiction are discussed. Game and bird refuges, areas under Federal control, national and international organizations, various phases of wildlife administration, and basic considerations of wildlife treatment and research are outlined.

KEYWORDS: Federal-State jurisdiction, research needs, administration.

359. Haugen, Arnold O.
1948. Bow 'n arrow hunting - good conservation. 13th Conf. North Am. Wildl. Trans. 13: 459-464.

Bow and arrow hunting is good conservation because it provides maximum hunter recreation per animal population with only one successful archer out of 30. There is not undue crippling of animals, and distances traveled by hit deer compare favorably with rifle-shot deer not killed immediately. Managers found no unclaimed arrow-killed deer. Deer killed by archers were recovered at an average distance of 308 yards during a 4-year count. This compares with 349 yards for guns. Bows are safer than firearms in thickly settled areas. Archery hunting is more fun due to the tougher chase. Brief history of bow hunting in Michigan since 1934 is given.

KEYWORDS: Management, archery, historical value.

360. Haw, Frank

1965. Economic values and conservation implications of fishing derbies. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 241.

KEYWORDS: Washington, economics.

361. _________ and Raymond M. Buckley

1968. The ability of Washington anglers to identify some common marine fishes. Calif. Fish Game 54(1): 43-48, illus.

Results of a survey involving the examination of fresh fish specimens by 909 Washington salmon anglers demonstrated the following: a consistent inability of anglers to identify small chinook and coho salmon (which comprised 75 percent of the test specimens) and 10 other species, an improved recognition of chinook salmon after receiving a simple clue, more difficulty in recognition of smaller coho salmon than larger ones, and infrequent use of recommended common names.

KEYWORDS: Fishing, characteristics, Washington.

362. Hawes, Harry B.

1934. A model State game and fish law setup. 26th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 26: 86-89.

An act is proposed to create a model State game and fish commission, and its duties and powers are defined.

KEYWORDS: Management, administration, legislation.

363. Hawkins, Arthur S.

1965a. Aldo Leopold's philosophy on quality, a review. Naturalist 17(3): 6-9, illus.

Aldo Leopold, the father of modern game management, admitted that no two people would agree on what constitutes sportsmanship or quality sport. His views on conservation have been brought together in *A Sand County Almanac*. Although an avid hunter, Leopold felt the intangible wildlife values exceeded the game bag. To him, wildlife held a definite place in American culture, and its recreational experience should foster a distinctly American tradition of self-reliance, hardihood, woodcraft, and marksmanship. "Wildlife administrators," he said, "are too busy producing something to shoot." While ignoring the cultural values, American sportsmen do not realize that "outdoor recreation is primitive, atavistic, that their value is a contrast value, and that excessive mechanization destroys contrast...." Reaping wildlife by modern mentality rather than modern machinery yields pleasure and wisdom. A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. Otherwise it is wrong.

KEYWORDS: Non-consumptive use, esthetics, literature.

364. _________

1965b. Quality in waterfowl management. Naturalist 17(3): 28-31, illus.

A complete statement of the Mississippi Flyway council's policy on qualitative management included the following. Management objectives include preserving a sport and a tradition. Management should encourage conditions

so wild birds can avoid being shot, while the hunter has to draw on his skill to be successful. The wild bird should be regarded as the trophy of the hunt. Heredity alone does not insure wildness; environment greatly affects the bird's actions. Management should work to preserve species diversity and abolish practices which cheapen the sport. Beyond that, the function of management is to discourage violators and to help train inexperienced hunters. A progressive approach to this problem has been initiated by the Mississippi Flyway Council.

KEYWORDS: Waterfowl, esthetics, management.

365. Hay, Keith G.
1960. An evaluation of Colorado's access problems. 25th Conf. North Am. Wildl. Nat. Resour. Trans. 25: 364-377.

Public lands blocked to free public access were inventoried in 1957-58 through six statewide and one national survey. Landowners were blocking access to 1,462,720 acres along with 522 miles of trout-stream fishing and 28 fishing lakes. Eighty-seven percent of the landowners refused to grant or sell right-of-ways to public land. A survey of other State Game Departments showed that 82 percent of the Nation's public lands were open to access. Several courses of action are outlined to open lands.

KEYWORDS: Fishing, access, Colorado.

366. Hayes, Frank A.
1964. Dig their graves Mr. Sportsman. Fla. Wildl. 17(10): 20-25, 34, illus.

White-tailed deer in Southeastern United States, once massacred, then plagued by screw worms, are now experiencing a population explosion, exceeding range capacity, and starving. Supplemental feeding by man is not the answer. Sportsmen are "the only controlling factor...to keep deer healthy and alive," but they must first abandon antiquated sentiments supporting an outdated Buck Law. Where deer are too plentiful, a doe should be taken for each buck killed by a hunter. Overhunting can be corrected by the next fawn crop but overbrowsing is permanent.

KEYWORDS: Big game, either-sex hunt, historical value.

367. Hayes, J.
1967. New idea--fishing schools! Sportfishing 4(1): 48-49, illus.

The curriculum of a series of fishing schools established by the State of Pennsylvania includes casting techniques, fishing site selection, types of fish, and stream improvement. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Education, fishing.

368. Haygood, John L.
1965. Ten years' controlled hunting on Louisiana's wildlife management areas. 19th Conf. Southeast. Assoc. Game Fish Comm. Proc. 19: 160-170, illus.

Information on topography, management history, type of seasons, harvest statistics, hunter success, and local public pressure is given for nine Louisiana deer areas where daily permits are required. Generally, no daily or seasonal limits are set on hunter numbers. Such a high hunter density

has not resulted in an increase in hunting accidents. A large number of hunters on an area usually increased hunter success, and crippling loss was low since hunters killed each other's crippled deer.

KEYWORDS: Big game, Louisiana, safety, management, harvest statistics.

369. Haymes, Lon S.

1952. Basic laws as they affect water ownership and use. 42d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 42: 44-50.

An examination of the confused situation of landowner versus public water user reveals a lack of uniformity in precedents to guide the landowner, the sportsman, or the lawyer, a lack of effort to clarify the situation through the courts, and a tremendous need for unified action. Fishing, hunting, and other water uses are determined by the navigability of streams. If the stream is navigable, the fisherman or hunter is not a trespasser. Some States have broadened their definition of "navigable" in order to open more streams to public use. Examples of court decisions are summarized. Even non-navigable or non-floatable streams need not be considered lost to public use. Some States have attempted to enact old statutes.

KEYWORDS: Management, resource use, landowner-private.

370. Hazel, Robert B.

1968. The patrol area concept in wildlife law enforcement. 22d Conf. Southeast. Assoc. Game Fish Comm. Proc. 22: 547-550.

The new emphasis in law enforcement must be group effort although individual effort and initiative will still be used. Application of the patrol area concept in North Carolina is described.

KEYWORDS: Enforcement, North Carolina.

371. Head, Murdock

1962. Why does a man hunt? Va. Wildl. 23(8): 17-18, 21.

To the nonhunter, a man who leaves the comforts of home to endure the hardships of a camp is demented. For hunters, however, the contrast is important because life in camp is often diametrically opposed to life in the workaday world. There is a reversal of the social structure: the most respected man in the hunting camp may be unknown in his community. In camp the hunter returns to the basic problems of survival and to an existence that affords a simple, democratic environment. For many hunters, a few hours alone in the forest represent periods of their most lucid and objective thinking. The hunter is also motivated by an element of anticipation, by a mixture of the gambling spirit and the athlete. The logic of those who feel hunting should be prohibited varies from an interest in public safety to protecting wildlife. Hunting safety is being aided by education. Deer hunters are doing a real service by reducing herds, and most obey game laws and do not kill for the perverse pleasure of destruction. Killing is least important, and many hunters spend more time observing wildlife habits than in shooting.

KEYWORDS: Characteristics, philosophy, non-consumptive use.

372. Heald, Weldon F.

1963. A plea from a non-hunter. 43d Conf. West. Assoc. State Game Fish Comm. Proc. 43: 57-59.

A non-hunting nature enthusiast argues against the proposal to allow public hunting in the National Parks. Other large areas are set aside for hunting; small pieces should be saved for nature enthusiasts.

KEYWORDS: Refuge, administration, antihunting.

373. Hein, Dale

1967. Sources of literature cited in wildlife research papers. J. Wildl. Manage. 31(3): 598-599.

In the Journal of Wildlife Management, Volumes 28-30 (380 articles), three-fourths of 4,175 references were to periodicals. One-third of these references appear in *Journal of Wildlife Management, Transactions of the North American Wildlife Conference,* and *Journal of Mammalogy.* The 100 most-cited journals accounted for 75 percent of the references to periodicals, and 327 of the total of 599 serial publications were cited only once. A partial list of serial publication, in rank order of frequency, is included. Article is valuable for making recommendations for library acquisitions. All implications of data are entirely ignored.

KEYWORDS: Literature, library.

374. Hellyel, David

1949. Is bounty system a national farce? Tex. Game Fish 7(4): 6, 28.

Informal responses from questionnaires sent to the fish and game directors of the 48 States revealed that most States are moving away from the bounty system. The bounty, in most States, is more of a political football than a serious effort to control destructive mammals and birds.

KEYWORDS: Predator, surveys.

375. Hendee, John C.

1969a. Appreciative versus consumptive uses of wildlife refuges: studies of who gets what and trends in use. 34th Conf. North Am. Wildl. Nat. Resour. Conf. Trans. 34: 252-264.

Recreation based on appreciation of the natural environment is contrasted with consumptive forms of recreation such as hunting and fishing. Discussion includes who would receive benefits if refuges were managed to emphasize appreciative recreation uses versus consumptive, the intangible benefits that would be distributed, and the extent to which appreciative uses of natural resources are increasing relative to hunting and fishing.

KEYWORDS: Characteristics, esthetics, non-consumptive use, fishing, administration.

376. ________

1969b. Rural-urban differences reflected in outdoor recreation participation. J. Leisure Res. 1(4): 333-341.

This paper summarizes and discusses the various theories that attempt to explain the rural-urban variable. Hunting serves as an example of the theory that certain recreation activities are inherent in the life styles and values promulgated by rural versus urban residence. Studies reveal that hunting appeals to rural residents and blue-collar workers and the author's premise is that as young adults migrate to urban places, they may become less supportive of hunting activities because a new social group introduces them to a new set of values that are more appropriate to their social status.

KEYWORDS: Preferences, characteristics.

377. ________
1972. Management of wildlife for human benefits. 52d Conf. West. Assoc. State Game Fish Comm. Proc. 7 p. (mimeo).

Present evaluation of hunting benefits by days-afield and game bagged is not adequate. Today's conditions call for a more explicit emphasis of wildlife management on human benefits. A benefits-to-people philosophy of game management is proposed. It is based on the concept that hunting satisfaction consists of many dimensions and wildlife managers should view their jobs as managing for expression of these dimensions.

KEYWORDS: Benefits, philosophy.

378. ________ and Dale R. Potter
1971. Human behavior and wildlife management: Needed research. 36th Conf. North Am. Wildl. Nat. Resour. Trans. 36: 383-396.

Rigorous social-wildlife research is scarce, but behavioral research must be attracted to wildlife-people problems by money and by articulate definition of challenging problems for study. Research should be directed to several broad problem areas which include: hunting satisfaction, non-consumptive use of wildlife, the hunter population, access and hunting opportunity, wildlife economics, and political-legal issues. Specifically: What do people get out of hunting besides game? What are the philosophical and ethical aspects of hunting for sport? What are the extent and conditions under which non-consumptive uses of wildlife take place? How do characteristics of hunters compare with those of other recreationists? Under what conditions will private land be available for hunting or withdrawn? What is the value of hunting and fishing in comparison with other competing land uses? How do organizational and institutional factors affect wildlife management? Wildlife management education should include more social science and require money from a central source to support research at local levels. (Literature cited, 70.)

KEYWORDS: Administration, characteristics, non-consumptive use, economics, benefits, research needs, politics, access, philosophy.

379. Henderson, Dion
1955. Hunting in 2055. Wis. Conserv. Bull. 20(12): 14-15.

The use of an expensive general hunting license in conjunction with a license for various game animals is predicted. Fees will pay for conservation departments and multipurpose game lands. Hunters will wait their turn to hunt on game preserves where they will pay for whatever they bag. Hunting and restocking will thus pay for themselves.

KEYWORDS: User fee, management.

380. Henderson, Upton Bruce
1965. An economic analysis of the waterfowl resource of the Swan Lake National Refuge and the impact upon the rural community. Ph.D. diss., Univ. Mo., 175 p.

Major areas of inquiry were: determination of income generated from waterfowl hunting, demand for waterfowl hunting, and degree to which waterfowl hunting benefits have been capitalized into land values. Expenditures by all hunters using the refuge during the 1964 waterfowl season were about $500,000. Slightly more than $100,000 was spent for blind fees, and

restaurant purchases and transportation comprised the next largest categories of expenditures. In addition, $124,197 was spent locally by Federal and State agencies and personnel. The total economic impact of the 1964 waterfowl hunting season was over $600,000. Full potential of the Swan Lake Area has not been achieved, and residential service facilities are needed. Demand curves were developed from data on resident and non-resident hunter visits and distance traveled. An economic evaluation of the waterfowl resource revealed annual net benefits in excess of $20 million. Present value of the 120,000 Canada geese flock discounted over an infinite time at 2.5-percent interest was over $820 million. Effort to determine capitalization of waterfowl hunting benefits into land values was not highly successful. Unverified minimum and maximum additional value to lands surrounding the refuge attributable to waterfowl hunting was estimated to be $200 to $500 per acre. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Economics, waterfowl, refuge.

381. Hennessy, J. J. "Joe"
1962. Time of decision for our waterfowl - quantity or quality. Minn. Conserv. Volunteer 25(147): 3-7, illus.

The policy of the Mississippi Flyway Council is summarized as follows: the intangible values of waterfowl hunting--the esthetic, cultural, traditional, and therapeutic aspects--far outweigh the monetary values. The sport of duck hunting has degenerated greatly. Quality hunting requires appropriate surroundings, reasonable solitude, rugged exercise, suspense, excitement, and a chance to pit the hunter's skill against the innate cunning of the prey. As demand increases and supply diminishes, it is erroneously assumed that management should provide waterfowl hunting for everyone. Democratic hunter screening can be accomplished by requiring waterfowl identification tests, increasing fees, making hunting tougher, and outlawing the use of outboard motors. "Skybusting" must be controlled by either forfeiture of hunting license or limitation of the number of shells allowed per day. A final suggestion for regulating quality and increasing the pleasure per bir would be to limit the number of blinds per acreage.

KEYWORDS: Esthetics, waterfowl, benefits, management.

382. Henning, Daniel H.
1972. National Park wildlife management policy: a case study in decentralized decision-making. Northwest Sci. 46(2): 108-114.

During the summers of 1963 and 1964, data were gathered at the Rocky Mountain National Park from personal interviews, public documents, and correspondence. The paper deals with how decentralized decisions were made to deal with elk and mule deer populations which sometime increased beyond the carrying capacity of the winter range. From the establishment of the Park in 1915 to 1930, no negative comments were received on range conditions. However, after 1930 successively stronger comments were received on range deterioration. In 1943, shooting of surplus animals was initiated to reduce damage to the range. This reduction program failed in 1963 due to adverse public reaction, dislike by superintendents of the program, and general avoidance of unpopular or unpleasant conditions. The scientific collection and measurement of biological facts by experts do not necessarily result in the formation of theory upon which policy is based. Policy, instead, seems to result from the infusion of values into data with emphasis on the specialist in a supporting role for latent values of field wildlife personnel and park administrators.

KEYWORDS: Big game, administration, management.

383. Herrero, Stephen

1970. Human injury inflicted by grizzly bears. Science 170(3958): 593-598, illus.

The author studied records from four U.S. National Parks and seven Canadian parks, he interviewed and corresponded with persons involved in incidents with grizzlies, and he reviewed newspaper accounts and scientific articles. The probability of injury or death is very low: about one person per 2 million visitors is injured and about one person in 30 million visits is killed. In an 80-year period up to 1960, only 25 persons had been injured by grizzly bears, but during the 1960's when recreation visits drastically increased, injuries rose to five persons per year. These data are based upon 66 injury accounts and five deaths. Of these injuries 43 occurred while persons were camping in developed areas, and 24 others occurred while persons were hiking in back-country areas. A grizzly sow with cubs is most likely to charge if their "individual distance" has been intruded upon. Hikers who were attacked reported they had made no noise and were being very quiet. Surprise at close range was an important common element in hiking incidents. Talking or ringing bells would eliminate surprise encounters. Eighty-eight percent of the camping injuries occurred in Yellowstone Park where grizzlies have had extensive experience with garbage dumps. The bears may associate food with humans and therefore be more prone to attacking. Most bears flee from humans, some stand on their hind legs, some charge and retreat without contact, and the ones that make contact retreat very soon afterwards. "Playing dead" is suggested as a good, but not totally successful, strategy for minimizing injury.

KEYWORDS: Big game, non-consumptive use, refuge, accident.

384. Hewes, Gordon W.

1942. Economic and geographical relations of aboriginal fishing in in northern California. Calif. Fish Game 28(2): 103-109, illus.

Anthropologists define "fishing" as any operation engaged in to secure aquatic products useful to man. Products include food, ornament, fertilizer, or glue. Fisheries for food usually developed adequately, and fishing geography was nearly independent of local conditions which influenced the primitive economic utility of land plants and animals. Economically significant primitive fishing techniques were all mass methods. The outstanding economic effect of certain Indian techniques arose from the stability of their localization. Techniques used in aboriginal fisheries showed endless local variations due to geographical conditions. Accultural changes in Indian fishery are seen by the acceptance of new materials for hooks, harpoon points, and nets. Elaborate trout angling devices have not spread to the natives, however.

KEYWORDS: Historical value, fishing, economics, California, anthropology.

385. Hewston, John G., and Donald R. Franklin

1969. Recreational use patterns at Flaming Gorge Reservoir, 1963-65. USDI Bur. Sport Fish. Wildl. Serv. Res. Publ. 70, 80 p., illus.

This study consisted of 1,461 interviews with parties who represented 8,012 people, mail questionnaires sent to 3,000 local residents, a creel census of 1,060 fishermen, traffic counts, and agency records to determine visitor-use patterns. The number of visits increased from 231,065 in 1963 to 786,103 in 1965. In 1963 the primary purpose of the visit was sightseeing,

but in 1964 and 1965 fishing was the primary purpose of the visit. Hunting ranked about fifth among 12 categories. About 78 percent of those contacted expressed a willingness to pay for use of the reservoir. Eighty-four percent of the anglers caught fish. Degree of visitor satisfaction was registered on 17 items. Scenery came nearest to being "very satisfactory." Wildlife fishing, and boat-launching sites ranked slightly unsatisfactory. Awareness of wildlife was low; visitors had not heard the birds singing and were not aware of the many small creatures all around them, and those who saw and heard wildlife could not identify them. Yet when visitors were asked what they liked best, about half stated the "natural environment" which turned out to be scenery in most cases. (Visitor place of residence, party size, accommodations used, expenditures, and suggested improvements are included along with 13 references, the interview schedule, and the mail questionnaire.)

KEYWORDS: Fishing, Utah, Wyoming, user fee, benefits, economics, preferences.

386. Hewston, John Guthrie
1966. Development of recreational use patterns at Flaming Gorge Reservoir, 1963-1965. Ph.D. diss., Utah State Univ., 204 p.

From 1963 to 1965 recreational visitors were studied by interviews, creel censuses, mailed questionnaires, highway traffic surveys, and from State and Federal agency files. During 1963 sightseeing was the primary purpose of party visits, but when fishing was allowed in the reservoir it headed the list. Party size averaged 5.5 persons, with a length of stay from half a day to almost a full day. Parties spent $6 to $10 per visit. Other characteristics are given. (Condensed from *Dissertation Abstracts.*)

KEYWORDS: Utah, fishing, economics, characteristics.

387. Hibben, Frank C.
1955. Hunting goes to college. Field Stream 60(5): 52-53, illus.

A University of New Mexico (evening) course on hunting covered the use of rifles, shotguns, safety, tracking, game habitat, dressing and preparing of kill, use of dogs, waterfowl identification, camping; and equipment. Participants enjoyed outstanding hunting success the following year.

KEYWORDS: Education, New Mexico.

388. Hill, Hawley
1958. How can the States deal more effectively with the problem of non-residents purchasing resident licenses? 38th Conf. West. Assoc. State Game Fish Comm. Proc. 38: 317-320.

Idaho's 1957 legislation requiring proof of residence (such as a driver's license) resulted in a 63-percent increase in successful prosecutions of residency law violators, and it increased revenue by inducing nonresidents to purchase their proper class of license. To decrease violations, the State could employ more law officers, gain cooperation of motor vehicle licensing agencies, utility companies, and companies with directories such as telephone companies, and maintain records of past violators because they often return. Intrastate cooperation could include a central information filing system of all license buyers and potential violators, adopting a common definition of "residence," standardizing forms and licenses, and prohibiting the transportation of fully purchased licenses across State lines.

KEYWORDS: Economics, legislation, resident vs. nonresident.

389. _________
1965. Sport hunting laws and regulations - an infringement on the constitutional right to bear arms? 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 253-265.

The article criticizes stricter gun control laws since they would inhibit citizens who use firearms for hunting or hobby and cause a decline in sports hunting license revenues. The constitutional guarantee of the right to bear arms is the suggested basis for stopping gun control legislation.

KEYWORDS: Management, legislation.

390. Hill, R. G.
1938. Wildlife extension activities in Michigan. J. Wildl. Manage. 2(4): 235-238.

Objectives, procedures, and other information on extension problems and programs are outlined for three groups: sportsmen, farmers, and youth. Needed are the development of "aids to procedure" such as bulletins, movies, maps, newspaper articles, radio scripts, and demonstration areas.

KEYWORDS: Education, landowner-private, administration, Michigan.

391. Hill, Ralph R.
1950. Forest wildlife management in the Rocky Mountain region. J. For. 48(6): 419-422.

Forest Service, National Park Service, and Bureau of Land Management multiple use practices are reviewed. Fifty years of Forest Service operation are termed successful, but watershed management and grazing problems indicate that the region is particularly sensitive and requires management that diverges least from the natural. A discussion directed toward the future cites wildlife as a luxury, conservation as a matter of life or death, and the ability to distinguish between sustained yield and exploitation and to recognize that human problems are inseparable from land, plant, and wildlife problems.

KEYWORDS: Management, historical value, profession, conservation, resource use.

392. _________ and Erwin L. Boeker
1955. Hunting seasons and forest fires in Colorado. J. For. 53(10): 707-710, illus.

During 1943 to 1953, hunters were responsible for 303 forest fires (20 percent of all man-caused fires) on Colorado's National Forests. This averages one fire for each 2,500 hunters. Fires burned 1,825 acres and originated equally from smoking and camp or warming fires. Nonresidents comprise 18 percent of the deer hunters, and in 1952, four out of five convictions for failure to extinguish campfires involved nonresidents. Based upon fire danger ratings over the past 10 years, a hunting season opening 5 to 10 days later than usual would reduce the probabilities of large fires. The loss of revenue to the Colorado Game and Fish Department from the drop in non-resident deer and elk license sales due to postponement of season was $172,000 in 1952-53. Hotels, cabin camps, and outfitters also suffered financially.

KEYWORDS: Management, Colorado, economics, fire, resident vs. nonresident.

393. Hill, Russell G.
1940. Some observations on farm game management cooperatives in Michigan. J. Wildl. Manage. 4(4): 383-391, illus.

Michigan's cooperatives increased from one in 1936 to 110 in 1939. In 1936 the Department of Conservation supplied assistance at a cost of 1 cent per acre for 500,000 acres. Each cooperative adopts its own rules and regulations. Cooperatives reduce trespass, advance farmer education, aid game management, and stimulate social events. State participation has not increased paid hunting. Unfortunately, some farmers cooperate to control hunting trespass but give little attention to game production.

KEYWORDS: Michigan, management, landowner-private, economics.

394. Hilliard, E. H., Jr.
1962. Hunting and fishing in National Park areas. 52d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 52: 15-18.

Maintenance of an unimpaired Park ecology should not be compromised. Cropping of surplus wildlife should take place outside a Park. If surpluses must be harvested in a Park, then public deputies should be solicited only if they complete required training and work as part of a ranger-controlled team.

KEYWORDS: Resource use, big game, management, administration.

395. Hjersman, Henry A.
1951. The 1948 surveys of California's hunting take and their significance. Calif. Fish Game 37(1): 77-95.

Hunting success for the 1948 season in California was reported by a personal interview and concurrent post-card game take survey which indicated good correlation in the case of pheasants, but a 2½-times exaggeration of take for two lesser game species. Although useful in determining trends of game, post-card surveys do not disclose the actual take per species. Correlation of post-card and interview methods of securing game species kill by county is poor. Decreased sample size results in increased error.

KEYWORDS: Research methods, harvest statistics, California.

396. Hochbaum, H. Albert
1947. The effect of concentrated hunting pressure on waterfowl breeding stock. 12th Conf. North Am. Wildl. Trans. 12: 53-64.

A study of marshes in Canada's Lake Manitoba basin revealed a pronounced scarcity of breeding ducks. Excessive hunting pressure reduced duck populations that carried on living and breeding traditions affecting portions of the central flyway. Radical change in waterfowl legislation is needed to stop this "burning out process" and protect unit area and unit populations equally until a breeding population is established and controlled shooting applied.

KEYWORDS: Legislation, waterfowl, Canada.

397. ________
1948. Harvesting the waterfowl crop. 13th Conf. North Am. Wildl. Trans. 13: 481-492.

Author classifies the history of American waterfowling into three periods: meat hunting, waterfowling for sport, and high-pressure duck

hunting. The present period, high-pressure duck hunting, is fully evaluated. Waterfowling is presented as an art wherein the dead duck is important only if won by the ethics and rules of the game. Hunter pressure and commercialism are cited as reasons for a decline in sportsmanship. The management of man is cited as the most pressing problem in waterfowl conservation. Other aspects of waterfowling examined include: quality and quantity of the harvest, kill composition, harvest time and locality, and public attitude. A "we want our share of the flight" attitude by regions and States where ducks are not raised must be accompanied by willingness to share more responsibility for research and management.

KEYWORDS: Waterfowl, harvest statistics, historical value, management.

398. Hogarth, George R.
1934. Measuring what the sportsman should get for his license money and what he is actually getting. 26th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 26: 69-78.

Noted is the lack of tangible returns to hunters from expenditures for law enforcement, artificial propagation, State game refuges, and forestry.

KEYWORDS: Economics, administration, user fee, conservation.

399. Hogdon, Kenneth W.
1966. Wildlife and hunting on commercial forests in Maine. 31st Conf. North Am. Wildl. Nat. Resour. Trans. 31: 280-288, illus.

The more than $24 million spent in Maine illustrates the need for continuing and improving game habitat. Approximately 80 percent of Maine is forested. Land ownership patterns and climactic zones are discussed. Tabular data on deeryards which have been accepted by timber companies for management are included. Company attitude and sportsman response are cited as excellent.

KEYWORDS: Management, landowner-private, Maine, big game.

400. Hogsett, O. L.
1961. Yellow vs. red. N.D. Outdoors 24(5): 12-13, 15, illus.

A field color study in Illinois concluded that in bright sunlight yellow and red are seen equally well; but when light conditions are poor, yellow is recognizable almost twice as far.

KEYWORDS: Illinois, safety.

401. Holland, R. P.
1922. The public shooting ground--game refuge bill. 14th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 14: 63-67.

Discussed are the status of the bill and why it has not been passed.

KEYWORDS: Legislation, refuge.

402. Holland, Ray P.
1945. Thoughts of a duck hunter. 10th Conf. North Am. Wildl. Trans. 10: 35-38.

Paper criticizes the rejection of an advisory board for Federal administrators of the Migratory Bird Treaty and blames the Federal government for

cluttering the law with minor regulations that cannot be obeyed or enforced. Honest duck hunters become violators of the criminal code. To preserve duck "wildness," hunters should feed ducks. The prohibition of live decoys is criticized.

KEYWORDS: Waterfowl, management, philosophy.

403. Holm, Earl R.
1958. What about shooting preserves? N.Y. State Conserv. 13(3): 2-4, illus.

Popular article on New York's shooting preserves: their origin, function, and future. The sections on function and future are lacking detail, but there is a good history of New York preserves and how hunting evolved.

KEYWORDS: New York, historical value, plant and shoot.

404. Holmes, John M.
1946. Meeting the demands of the future angler. 11th Conf. North Am. Wildl. Trans. 11: 473-477.

A representative of Associated Fishing Tackle Manufacturers discusses problems to satisfy postwar demand for fishing equipment by the more than 15 million prewar fishermen. Discussion covers product delivery, supply and materials, procurement, quality and innovations, and projected costs.

KEYWORDS: Fishing, economics, historical value, equipment.

405. Hoover, Herbert
1964. The constructive joy of fishing. Nat. Wildl. 2(4): 36-37.

This is an excerpt taken from President Hoover's book, *Fishing for Fun and to Wash your Soul.*

KEYWORDS: Fishing, philosophy, benefits.

406. Hopkins, A. S.
1940. New York State's public fishing program. J. For. 38(6): 464-467.

An explanation of the policies and progress of the State's program of acquisition and improvement of public fishing areas since 1935 included the following information: half of the 1,000 miles of trout streams planned for acquisition have been purchased, improvements for control of environmental conditions have been constructed by the Civilian Conservation Corps and by State-employed labor, and program cost has averaged less than $500 per mile.

KEYWORDS: Fishing, administration, economics, New York.

407. Hosley, N. W.
1937. Some interrelations of wildlife management and forest management. J. For. 35(7): 674-678.

It is suggested that forestry plays an important part in the approach to wildlife problems from the standpoint of maximum land use. Fundamental information gained by biological surveys is cited as more valuable than wholesale stocking in terms of long range recreation.

KEYWORDS: Management.

408. ________ W. W. Chase, S. A. Graham, R. T. King, E. B. Moore, H. L. Shantz, and W. P. Taylor
1944. What can forest wildlife contribute to the war program? J. For. 42(5): 361-363.

Report of game management committee of Society of American Foresters reveals that wildlife can contribute significantly to wartime shortages of meat, skins, fats, and bird down. Recreational value of wildlife contributes to morale of workers. In 1942, meat from big and small game totaled over 1 million pounds, was worth about $42 million, and could supply a million people for a year. Only one-fourth or 160,000 of the total deerskins reached tanneries. Skins are valued for merchant marine and arctic clothing. During the trapping season over 94 tons of fat were saved from fur bearers in Pennsylvania. With better prices hundreds of tons would be available. Bird down is drastically needed for sleeping bags and coats. Streams, lakes, and ponds on National Forests can produce about 22 million pounds of fish per year. Despite restricted wartime travel and shortages of ammunition and equipment, license sales have decreased only slightly. Over 2.6 million sportsmen put in 6.4 million days of use. Legislation and educational campaigns consistent with conservation are needed to improve wildlife's contribution to war efforts.

KEYWORDS: Economics, benefits, harvest statistics, legislation, historical value.

409. Houck, Warren Jacob, Jr.
1949. A study of conservation education on the wildlife refuges of the United States, a report and recommendations. Ph.D. diss., Cornell Univ., 418 p., illus.

Questionnaire sent to over 100 wildlife refuges, sanctuaries, and preserves in 35 States and personal visit to 34 national refuges are basis for description of characteristics of wildlife areas accompanied by maps and photos. Wildlife education programs are recommended. Five criteria are presented for establishing wildlife conservation and education programs. An excellent history of wildlife refuges is traced to time of Christ, with details on refuge development in United States. Conclusions based mostly on personal observation and judgment. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Refuge, surveys, historical value, education.

410. Howard, Walter E., and William M. Longhurst
1956. The farmer-sportsman problem and a solution. 21st Conf. North Am. Wildl. Trans. 21: 323-330.

Poor access management makes wildlife unavailable to the sportsman. The potential value of the hunting resource exceeds that of many other land and water uses, or at least will pay land taxes. This profit motive should be used to encourage landowners to develop fish and game as an agricultural crop. Training in agronomy, husbandry, and habitat management will be necessary for the landowner who is to design stringent hunting stipulations and properly maintain the hunting resource. Hunting quality, proximity to human population, cabins, duck blinds, and boats are all factors contributing to the value of the hunting resource on private land.

KEYWORDS: Landowner-private, user fee.

411. Howell, Henry H., and Harland R. Lutz
1961. How many out-of-state fishermen purchase more than one license in Kentucky, and where and when do they fish? 15th Conf. Southeast. Assoc. Game Fish Comm. Proc. 15: 367-379, illus.

Since the distribution of Federal Dingell-Johnson funds to the States is determined in part by the number of out-of-State licensees fishing in a State, Kentucky checked its license sales to determine the number of duplicate 10-day non-resident fishing license purchases. The final count revealed 1,824 duplicates, 188 triplicates, 27 quadruplicates, 2 quintuplicates, and 1 sextuplicate, or a total of 4,336 licenses for 2,042 persons. These purchases were made primarily in the 17 counties which surround the State's five largest manmade lakes. Purchasers often traveled great distances to fish in Kentucky. Also determined were age, sex, and where and when the purchaser fished.

KEYWORDS: Fishing, research methods, Kentucky, characteristics.

412. Hubbard, Douglass H.
1942. The development of the rifle and its relation to wild game in North America. M.S. thesis, Texas A&M Univ., 131 p.

A history of the American rifle includes the influence of military rifles, the influence of the westward migration of people, and the rifle's relation to big game destruction. Also included are the attitudes of State game commissioners toward regulation and control of firearms. Of the 37 States with open big game seasons, 14 have regulations restricting firearms and projectiles which may be used to hunt animals.

KEYWORDS: Historical value, legislation.

413. Hudoba, Michael
1954. What's wrong with public relations in the western States? 34th Conf. West. Assoc. State Game Fish Comm. Proc. 34: 91-96.

Rambling discussion on public relations criticizes the lack of public understanding of policies, a lack of communication, authority, and funds, and a failure to take a strong stand on basic resources affecting wildlife such as water pollution and erosion.

KEYWORDS: Administration, public relations.

414. Humphreys, Robert H.
1953. Early hunters in Texas. Tex. Game Fish 11(10): 16-19, illus.

KEYWORDS: Texas, historical value, tradition, big game.

415. Hunt, John D.
1971. Utah's economy and the non-resident deer hunter. Utah Sci. 32(3): 91-92.

During 1970, a diary questionnaire was given to 450 hunter parties but returned by only 72. It indicated that non-resident hunters contribute relatively little to the State's economy. Nonresidents contributed substantially to game management with a $50 non-resident license fee and to the economies of certain communities. Hunter parties spent an average of 4.8 nights in Utah and spent less than $4 per day per person.

KEYWORDS: Utah, resident vs. nonresident, economics.

416. Hunt, Richard A., J. G. Bell, and L. R. Jahn

1962. Managed goose hunting at Horicon Marsh. 27th Conf. North Am. Wildl. Nat. Resour. Trans. 27: 91-106, illus.

The development of goose hunting opportunities and goose harvest regulation in the vicinity of the Horicon National Refuge from 1949 to 1961 is traced. Peak Canada goose populations increased from 12,000 in 1949 to 100,000 in 1961. Hunters averaged 6.5 trips per year, 2 hours per trip, 0.08 goose per trip, and fired 27 shots per goose bagged. Regulations to increase hunting opportunity, to improve hunting conditions, and to increase but not exceed the goose harvest are listed.

KEYWORDS: Management, refuge, harvest statistics, Wisconsin, waterfowl.

417. Hunter, G. N.

1949. "Uncontrolled" big game hunting. 39th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 39: 77-83.

Paper presents a brief discussion of the management and psychology of either-sex hunts as they relate to the sportsman.

KEYWORDS: Either-sex hunt, big game, Colorado, harvest statistics, benefits.

418. Hunter, Gilbert N.

1949. The utility of personal interviews in obtaining information on game and fish resources. 14th Conf. North Am. Wildl. Trans. 14: 239-252, illus.

A summary of the 1946 Colorado survey (the first instance of statewide application of the interview technique) includes scope, requirements, method, cost, and accuracy. The random interview method yielded sufficiently accurate information for administrative use. Survey findings are tabulated, and data on the economics of hunting and fishing, records of small game kill and wounding losses, sportsmen's preferences, and landowner problems were obtained. This is early information on survey techniques for wildlife-people research.

KEYWORDS: Administration, research methods, harvest statistics, Colorado.

419. ________

1957. The techniques used in Colorado to obtain hunter distribution. 22d Conf. North Am. Wildl. Trans. 22: 584-593, illus.

Proper hunter distribution can be obtained by effective administration, adequate Game and Fish Commission authority, and regulations of opening dates, season length, and season types. Hunters are commonly distributed by liberal bag limits, area size, TV and radio programs, news and magazine articles, and weather and range conditions.

KEYWORDS: Crowding, Colorado, management.

420. ________

1959. Management values of Colorado's elk validation system. 39th Conf. West. Assoc. State Game Fish Comm. Proc. 39: 209-212.

Paper suggests that the proper management of elk can best be achieved by the elk validation system, whereby the hunter obtains a special permit (in addition to the regular antlered elk license) which entitles him to take an elk of either sex.

KEYWORDS: Colorado, big game, management.

421. Hunter, W. A.

1953. Landowner-sportsman relations. 33d Conf. West. Assoc. State Game Fish Comm. Proc. 33: 265-269.

Originating with organized sportsmen, Washington State's initial farmer-sportsman program failed without Game Department participation. Now under Game Department administration, field representatives solicit agreements from landowners to switch from "No Trespassing" to "Hunting by Permission" or "Hunting without Permission." Results for 1950 showed 924 farmer participants or 95 percent of those contacted and 490,000 additional acres opened for hunting. In 1951, 1,324 participated, with 758,619 acres opened. A 5-year program evaluation suggests: Game Department administration of all farmer-sportsman programs; access to land should be considered a privilege, not a right, with the landowner benefiting least; public opinion is critical to success; and methods to maintain high interest and enthusiasm are necessary.

KEYWORDS: Fishing, farmer-sportsman relations, Washington, management.

422. Hutchins, H. Clifton, and Edgar W. Trecker, Jr.

1961. The State park visitor. Wis. Conserv. Dep. Tech. Bull. No. 2, 82 p., illus.

In 1958, 20,262 motorists in Wisconsin were interviewed in State parks and forests. More than one-third came principally for sightseeing; 19 percent for picnicking; 17 percent for camping; and 14 percent for swimming. Boating, nature study, fishing, and resort use attracted relatively small numbers. The average income of State park visitors was $5,551. The average reported income of northern forest visitors was nearly $1,000 higher ($6,516) than that of State park visitors. The average expenditure was $16.38. Four out of five visitors came to the parks for 1 day only; 4 percent stayed a week or longer.

KEYWORDS: Fishing, Wisconsin, non-consumptive use, economics, characteristics.

423. Hutter, Irvin Russell

1960. Land use trends and their impact upon wildlife and hunting trends in Rock County, Wisconsin. M.S. thesis, Univ. Mich., 89 p.

Restricted to University of Michigan campus use.

KEYWORDS: Resource use, Wisconsin.

I

424. Irving, Frank Dunham

1960. A study of the relationship between program and organization in the administration of forest and wildlife resources by the State of Minnesota. Ph.D. diss., Univ. Minn., 348 p.

Examines program and organization relationships in the Division of Forestry and the Division of Game and Fish of the State's Department of Conservation. The purposes, methods, and results obtained are explained in the descriptions of the programs. Statutory authority to determine the structure of department divisions is assigned to the Commissioner of Conservation, but much of this power is delegated to division directors. In the assignment of tasks to positions, work is usually concentrated to develop special skills, and the capacity of the individual is recognized as a limiting factor. Structure decisions are often influenced by future expectations of growth, career opportunities, job security, station location, employee associations, and a desire to avoid conflict and competition with other units of government. Four technical aspects of forestry and wildlife operations influence work division: location, timing, techniques, and facilities. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Administration, Minnesota.

425. Isakovic, Ivan

1970. Game management in Yugoslavia. J. Wildl. Manage. 34(4): 800-812, illus.

Wild game is a common social possession and hunting estates are established on the basis of natural habitat units regardless of land ownership. Amateur sports organizations manage 90 percent of the habitat. To hunt, sportsmen must belong to a hunting organization, pass examinations, and pay fees established for each species. Membership fees range from $32 to $64 per year depending upon the organization and the type of trophy desired. Popular game species include red deer, roe deer, chamois, brown bear, and hare. Many upland birds are produced by artificial rearing programs.

KEYWORDS: Foreign country-general, management, landowner-public, license fee, clubs, landowner-private.

J

426. Jackson, Bud

1952. Conservation's missing link - the wildlife journalist. 17th Conf. North Am. Wildl. Trans. 17: 510-518.

KEYWORDS: Public relations, education, communications.

427. Jackson, Charles E.

1940. The relationship of commercial and sport fishermen. 5th Conf. North Am. Wildl. Trans. 5: 46-54.

Charged with favoritism, the Bureau of Fisheries replies that it is not commercial fish minded, nor game fish minded, but fish conservation minded. Although the Bureau annually produces 7 billion of commercial species and only 1 billion of game species, the cost of producing commercial fishes is only $21 per million while the cost of game species production averages $6,146 per million. About 80 percent of the Bureau's fish culture appropriation is expended for the production of game species. Sport fishermen's strength in influencing public opinion outweighs that of commercial fishermen who have not increased in total number (130,000) from 1933-38, while licensed anglers increased from 4,858,059 to 7,436,177 during the same years. A well regulated commercial fishery cooperating with anglers is the only solution. The combined influence of both groups of fishermen is essential for conservation but is not realized because commercial fishermen are not organized.

KEYWORDS: Fishing, economics, resource use.

428. ________

1944. Cooperation between game and commercial fishery interests. 9th Conf. North Am. Wildl. Trans. 9: 224-229.

It is estimated that there are 15 million anglers and 130,000 commercial fishermen in the country. Fighting between these groups results in neglect of the fishing resource. Examples are cited of arguments and of cooperation between commercial and sport fishermen. It is suggested that magazine stories on conservation in both fields could help to unite the two groups.

KEYWORDS: Fishing, resource use.

429. James, George A., Harold K. Cordell, Frank B. Barick, and Robert L. Downing

1969a. Small-game hunting on western North Carolina wildlife management areas. Part I. Characteristics of hunters. Wildl. N.C. 33(10): 8-10, illus.

Information about small game hunters was collected by interview of 553 hunters from five wildlife management checking stations during 1964 and 1965. The average small game hunter is male, married, a resident of North Carolina, living in a rural area within 50 miles of the wildlife management area in which he hunts, about 40 years old, a high school graduate, and earning about $5,000 a year as a blue-collar worker. He is an enthusiastic hunter, walking about 3 miles on each hunting trip. He hunts about 2.5 times each season on wildlife management areas and about 10.5 times per season off these areas. He uses access, but prefers to hunt away from it, penetrating about 1,100 feet into the forest. More early-season than late-season hunters were single, rural residents, and they lived closer to the

management area in which they hunted. They were a little older, had slightly less formal education, and had lower incomes than late-season hunters.

KEYWORDS: North Carolina, access, small game, characteristics.

430. ________ Harold K. Cordell, Frank B. Barick, and Robert L. Downing
1969b. Small-game hunting on western North Carolina wildlife management areas. Part II. Importance and use of forest roads and trails. Wildl. N. C. 33(11): 10-12, illus.

Interviews with 553 small game hunters (15 percent of the hunters who used the areas) yielded the following information: most small game hunting was closely tied to access. The excellent network of well-spaced roads and trails permitted ready access into most sections of each management area by vehicle and by foot. Most hunters indicated by word and action that access was important. Although most of them did not hunt primarily along developed access, they used this access to gain entry into the forest, where they covered considerable cross-country distance. Hunting pressure was well dispersed on each of the five study areas.

KEYWORDS: Crowding, North Carolina, access, small game, harvest statistics.

431. ________ Frank M. Johnson, and Frank B. Barick
1964a. A key to better hunting--forest roads and trails. Wildl. N. C., 2 p., illus.

Access as a tool can produce uniform deer kill and reduce hunter hazard by distributing hunter use. Over 4,100 deer kill locations were plotted on 13 management areas in western North Carolina during four hunting seasons (1959-62). Approximately 40 percent of all areas checked were within 300 feet, and 65 percent within 600 feet, of the nearest road or trail. Hunting pressure diminished rapidly beyond 600 feet, and no deer were killed beyond 1,800 feet in the Piedmont area. In contrast, mountain hunters killed 30 percent of their deer 601 to 1,200 feet from a trail. Roads and trails served about equally in obtaining uniform kill.

KEYWORDS: Crowding, big game, North Carolina, access.

432. ________ Frank M. Johnson, and Frank B. Barick
1964b. Relations between hunter access and deer kill in North Carolina. 29th Conf. North Am. Wildl. Nat. Resour. Trans. 29: 454-463, illus.

A cooperative study plotted deer kill locations on 13 wildlife management areas in western North Carolina during four hunting seasons, 1959 to 1962, and on the Uwharrie Wildlife Management Area during 1960-62. Successful hunters assisted in plotting kill locations on maps, which yielded 502 locations from the Uwharrie and 3,663 from western North Carolina. Approximately 40 percent of each wildlife management area was within 300 feet of some road or trail, and 63 percent was within 600 feet. Less than 20 percent of the total forest was beyond one-half mile from either road or trail. Successful hunters in western North Carolina used all portions of the forest and were often rural residents. Hunters in the Uwharrie stayed much closer to access, did not generally penetrate remote sections, and were generally city dwellers. The western areas have uniform kill distribution and do not need the additional roads or trails which may be desirable for the Uwharrie region. Roads and trails serve about equally in distributing successful hunting pressure. Good trails are less costly and more desirable esthetically than roads.

KEYWORDS: North Carolina, access, big game.

433. _________ Nelson W. Taylor, and Melvin L. Hopkins
1971. Estimating recreational use of unique trout stream in the coastal plains of South Carolina. USDA For. Serv. Res. Note SE-159, 7 p., illus. Southeast. For. Exp. Stn., Asheville, N. C.

A questionnaire was attached to vehicles belonging to fishermen who were using a rainbow trout stocked stream. Twenty sampling days were selected within an 135-day use period. Seventy-seven percent of the groups receiving the questionnaire completed it. This amounted to 66 completed questionnaires. Linear regression was used to estimate use and its relationship with the traffic-flow pattern. The latter was a weak relationship. Fisherman use was estimated at 1,025 with confidence interval of ± 24.9 percent. Mean size of fishing groups was 2.3 persons. Nineteen percent caught their limit and 70 percent caught at least one fish. The cost of trout stocking was $1,073.

KEYWORDS: North Carolina, fishing, economics, management, harvest statistics.

434. Jamsen, G. C.
1967. Sex and age structure of licensed hunters, trappers and fishermen in Michigan. Mich. Dep. Conserv. Res. Dev. Rep. No. 125, 14 p.

Utilizing data from fishing and small game hunting license purchases, this report lists the age and sex distribution of resident and non-resident small game hunters, firearm deer hunters, bow and arrow deer hunters, trappers, bear hunters, and fishermen. Data are presented for the years from 1962 to 1966 and in some cases go back to 1949.

KEYWORDS: Michigan, fishing, small game, trapping, characteristics, big game, resident vs. nonresident.

435. Janzen, Daniel H.
1961. Report on the 1960 National Survey of Fishing and Hunting. 51st Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 51: 24-30.

Highlights of the survey are reviewed.

Keywords: Surveys, fishing.

436. Jarman, Ron, Charles Bennett, Charles Collins, and Bradford E. Brown
1967. Angling success and recreational use on twelve state-owned lakes in Oklahoma. 21st Southeast. Assoc. Game Fish Comm. Proc. 21: 484-495, illus.

Twelve State-owned lakes, unmanned and ranging in size from 26 to 180 surface acres, were surveyed in Oklahoma in 1965 to obtain data on sport fishing and recreational use. Average harvest in pounds per acre ranged from 22 to 107, with fishing pressure ranging from 138 to 622 hours per acre. Most of the fishing effort was expended from April through October. Other recreational use, mainly sight-seeing, camping, and picnicking, rivaled fishing in number of participants on lakes.

KEYWORDS: Oklahoma, fishing, characteristics, harvest statistics, non-consumptive use.

437. Johnson, A.
1967. Hunting, fishing and private enterprise. Idaho Wildl. Rev. 19(6): 3-7, illus.

Idaho's public land for recreational purposes can be attributed to private enterprise. Plentiful fishing and hunting opportunities through landowners' generosity render shooting preserves and fee hunting necessary. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Landowner-private, user fee, refuge, Idaho.

438. Johnson, Arlie
1964. The role of private enterprise in providing fishing and hunting recreation in Idaho. 44th Conf. West. Assoc. State Game Fish Comm. Proc. 44: 96-102.

Industries, private organizations and associations, power companies, ranchers, and farmers in Idaho have provided continued and expanded fishing and hunting opportunities. Idaho must rely heavily upon the operations of outfitters and guides to obtain even the minimum desired harvest of some big game herds. There is ample space and wildlife stock capable of withstanding an even higher level of fishing and hunting recreation use. Private enterprise supporting recreation by providing opportunity is not expected to ever take a leading role such as through the establishment of shooting preserves.

KEYWORDS: Fishing, economics, Idaho, landowner-private, guide.

439. Johnson, Fred W.
1943. Hunter distribution - studies and methods. 8th Conf. North Am. Wildl. Trans. 8: 392-407, illus.

The early season peak of hunting effort is the central problem in securing better seasonal hunter distribution. Important related factors include hunter psychology, accessibility to hunters, distribution or occurrence of game, topography, special seasons, and licenses. Hunter distribution studies on southwestern National Forests show a high percentage of the game is killed within 1 mile of an automobile road. Reduction of hunting effort and total kill can be secured through short limited hunts or by opening the season later than usual. A reduction of the heavy harvesting of immature bucks results in bigger and better deer. When both sexes are taken, increased hunter effort is paralleled by an increase in hunter success.

KEYWORDS: Management, either-sex hunt, big game, harvest statistics, research methods, crowding.

440. __________ and D. I. Rasmussen
1946. Recreational considerations of western big game hunt management. J. For. 44(11): 902-906.

The primary objective of big game management is recreational in character and purpose. Administration requires that hunters be permitted a degree of isolation compatible with good sport and herd management, that hunting be distributed seasonally and spatially, that seasons and bag limits provide the greatest sport possible, and that hunting regulations permit efficient utilization of increases in herd size. Quality recreation decreases with overcrowding on easy access areas and by underhunting on the inaccessible areas. Five methods proposed for improving big game hunting are: hunting on the basis of herd area rather than on political subdivisions, distribution of hunting throughout the season and over the game ranges, increase of adult survival and rate of herd replacement, development of new herds, and improvement of habitat.

KEYWORDS: Big game, non-consumptive use, management.

441. Johnson, Huey D.
1966. A study of organized efforts to improve landuser-sportsmen relations for the purpose of maintaining public upland game hunting. M.S. thesis, Utah State Univ., 79 p.

A mail questionnaire was sent to 14 State game departments which had active landowner-hunter cooperative programs. The objective was to ascertain the elements of a successful program and to make recommendations for other States. A visit and personal interview were made to eight of the States to review programs as they actually existed. Approaches to landowner-sportsman relations included the use of shooting preserves, cooperative leasing, tax relief, educational programs, trespass control, and financial payment for damage. (Included are 108 references and questionnaire.)

KEYWORDS: Surveys, upland game birds, landowner-public, farmer-sportsman relations, plant and shoot, access, education, landowner-private.

442. Johnson, J. L.
1967. Archery affects Engligh history, TAM Archery World 16(12): 52-55, illus.

The history and folklore of the bow and arrow in England are discussed. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Archery, historical value, England.

443. Johnson, Sam L.
1954. Scientists in the Fish and Wildlife Service - a case study in the recruitment and retention of federal scientific personnel. M.S. thesis, N.Y. Univ., 149 p.

This organizational study includes a history of the Fish and Wildlife Service, recruitment of personnel including supply and demand, retention of personnel, training, deterrents to recruiting and retaining the best qualified personnel, advantages of Federal employment, the history and significance of American wildlife, and biologists in the field of wildlife conservation.

KEYWORDS: Profession, education, historical value, management.

444. Jones, Walter B.
1957. Views of sportsmen on game and fish laws. 11th Conf. Southeast. Assoc. Game Fish. Comm. Proc. 11: 197-201.

Hunting has declined as a sport because of habitat loss and senseless violations of necessary game regulations, according to one Alabama sportsman.

KEYWORDS: Management, Alabama.

445. Joselyn, G. Blair
1965. Wildlife management on military installations--a critique of Army policy. J. Wildl. Manage. 29(1): 215-224.

The Department of Defense controls increasingly larger segments of U.S. land (28.7 million acres in 1963). Civilian conservation agencies, backed by Federal legislation and Defense Department policy statements, have urged natural resource management. Long-range wildlife resource planning by the Air Force and the Navy has not been paralleled by the Army's land management orientation which largely ignores recreational values. Army

installations at Fort Riley, Kansas, have developed a program demonstrating hunting and fishing popularity, but recreational value of fish and game for military personnel has been neglected.

KEYWORDS: Non-consumptive use, management, fishing, landowner-public.

K

446. Kathrein, Joseph W.
1953. An intensive creel census on Clearwater Lake, Missouri, during its first four years of impoundment, 1949-1952. 18th Conf. North Am. Wildl. Trans. 18: 282-295, illus.

A total of 11,387 creel records were obtained during the census. Average catch per hour declined from 0.65 fish in 1949 to 0.34 in 1952. Relative abundance of different species caught changed each year. Fisherman counts showed an average of 30 fishermen per day in 1949, 41 in 1950, 42 in 1951, and 32 in 1952. Fishing intensity was greatest in the summer except during 1952 when it was greatest in the spring. An estimated 95,175 days of effort were expended and total catch was estimated at 47,125 fish in 1949, 51,775 in 1950, 96,625 in 1951, and 45,450 in 1952. Fish were taken at the rate of 6.8 pounds per acre in 1949, 10.4 in 1950, 31.3 in 1951, and 15.2 in 1952. In general the average lengths for all species of fish in the creel increased during the 4 years.

KEYWORDS: Harvest statistics, fishing, Missouri.

447. Keating, James
1965. Economic values and conservation implications of fishing derbies. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 238-240.

Sport fishing should not be done to promote the economy but, rather, for its sport. Derby participants place a high value on the prize and a low value on sporting aspects. Local promotional groups often plant hatchery fish in unsuitable waters.

KEYWORDS: Fishing, economics, Idaho.

448. Keener, John M.
1956. A new deal for deer and hunter. Wis. Conserv. Bull. 21(12): 3-9, illus.

Wisconsin's deer harvest could be permanently increased by a program of range improvement and controlled hunting. A committee appointed to study deer seasons and harvest methods concluded that harvest would increase by establishing seasons for designated areas rather than on a statewide basis and by establishing an integrated deer habitat program. The actual method of harvest is designed to entice hunters into areas where the largest surplus of deer exists.

KEYWORDS: Big game, Wisconsin, management.

449. Keim, Charles J.
1965. A sportsman looks at State information efforts and responsibilities. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 310-312.

Sportsmen have a right to expect the State, the legislators, and the media to cooperate in favor of wise maximum utilization of the outdoors.

KEYWORDS: Administration, public relations.

450. Kelker, George Hills
1943. The state-sportsman-landowner triangle. J. Wildl. Manage. 7(1): 7-10.

The weaknesses of the State-hunter-landowner triangular system include: failure of the State to provide sufficient hunting areas and game or to fully recognize the landowners' position, disproportionate take of game by hunters, lack of safeguards against species extermination, failure to properly compensate the farmer, and lack of attention to the requirements of game species. Listed are 13 ways in which the State should lead in game improvement and farmer-sportsman relations.

KEYWORDS: Management, farmer-sportsman relations.

451. ________
1964. Appraisal of ideas advanced by Aldo Leopold thirty years ago. J. Wildl. Manage. 28(1): 180-185.

The evidence of 30 years' use of game management suggested by Aldo Leopold shows that many ideas have been accepted and are still prominent in the wildlife profession. These include game management, concepts of species cycling, restocking interspersion and dispersion of habitat features, and census taking, to name a few. Philosophy of the new profession is also presented.

KEYWORDS: Literature, management, historical value, philosophy.

452. Kelley, Charles D.
1960. Public relations--its value as a tool of enforcement. 14th Conf. Southeast. Assoc. Game Fish Comm. Proc. 14: 269-271.

Five objectives for a good public relations program include: employees must have proper understanding of the directives and policies under which they work, enforcement officers should be encouraged to suggest improvements in laws, employees should be encouraged to take disagreements to the boss not the public, public fighting between State and Federal agencies should stop, and violators should be arrested only in light of conclusive evidence.

KEYWORDS: Enforcement, public relations.

453. Kelley, Claude D.
1954. What our courts must learn: game laws are no joke. Fla. Wildl. 7(9): 12-15, 38, illus.

Examples show how various State courts sentence game law violators. For example, suspended sentences and reprimands are regularly handed down in cases which should be treated as serious offenses. In North Carolina game violations carry minimum fines of $25 to $50, but the average in 1953 was less than $9.

KEYWORDS: Enforcement, education, law violation.

454. ________
1957. Politics in State game and fish agencies. 11th Conf. Southeast. Assoc. Game Fish Comm. Proc. 11: 11-17.

Data obtained by questionnaire from 47 States on the problem of partisan political abuses and controls show an increasing freedom from political abuses and an honest recognition of yet-existent shortcomings. For instance, 43 States said their wardens do not change with a change in partisan control of State government, and 37 States said their game commissions have all or part of the regulation-making authority.

KEYWORDS: Politics, administration, surveys.

455. Kelley, John William

1968. An analysis and evaluation of New York State's fish and wildlife management act. Ph.D. diss., Cornell Univ., 346 p.

An analysis and evaluation are made of the organization, functioning, and accomplishments of the first 10 years of New York State's Fish and Wildlife Management Act. Tested were 51 hypotheses concerning program operation and functioning. A review was included of published and unpublished policy memoranda, special reports, and the minutes of 431 Regional and State Board meetings. Former and current board members (441) were contacted by questionnaire with 63-percent return. Conservation Department personnel (75) and cooperating landowners (112) were interviewed. After 10 years of operation, 44 public hunting or fishing areas have been established on 276,411 acres of private land. Eighteen specific recommendations for improvement are offered. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: New York, administration, legislation.

456. Kennedy, James Joseph

1971. A consumer analysis approach to recreational decisions: deer hunters as a case study. Ph.D. diss., Va. Polytech. Inst. State Univ., 194 p.

A general conceptual model of recreational behavior is proposed and the feasibility is examined of applying such a model to a recreational activity like deer hunting. The study is based upon 373 questionnaire responses (82-percent return) of resident deer hunters using the Pocomoke State Forest, Maryland, during the 1969 season. Most of the respondents had less than 5 years' deer hunting experience. Although hunter success was 2.7 percent, only 14 percent stated they had a poor or very poor time. Hunters stated that other hunters in the area help move deer but cause crowding, competition, and a safety hazard. The findings suggest that the general model is an appropriate and useful framework for the analysis of deer hunter behavior. It appears that with detailed research most of the model's major components could be quantified to explain how deer hunters behave. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Big game, Maryland, characteristics, research methods, non-consumptive use.

457. Kenney, Raymond J.

1932. Combination licenses vs. separate licenses. 24th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 24: 46-49.

Paper advocates the return to separate licenses and abandonment of the combination license system.

KEYWORDS: Massachusetts, license fee, management.

458. Kern, E. E., and L. S. Driscoll

1966. Marketing of outdoor recreational services in rural areas. J. Soil Water Conserv. 21(4): 141-143, illus.

Increasing acreage is being converted from farmland to recreation use. The feasibility and profitability of such enterprises has been questioned. A study of 55 private, outdoor recreational facilities in Alabama was made to determine their degree of success and reasons for it. The results indicate only nine of 55 operators had had any previous experience in marketing outdoor recreation services. Of 55 operators about 33 percent

failed to realize positive returns to family labor and management, and 60 percent made less than $500 annually. Average investment per establishment ranged from $11,000 to $70,000. Lack of patronage was a major problem for all operators. Study and extensive planning for those interested in the marketing of rural outdoor recreation services are necessary. Requirements include a favorable location, quality services, managerial competence, pleasing personality, and marketing techniques.

KEYWORDS: Landowner-private, economics, Alabama.

459. Khalili, Abdolamir
1969. Optimal economic management of wildlife, over time, with special reference to Canadian geese of the Swan Lake Wildlife Refuge. Ph.D. diss. Univ. Mo., 189 p.

Study provided an operational decision model which can be used to determine the harvest levels, over time, that maximize the present value of expected net social benefit associated with any species of wildlife over a planning horizon. Using demand for Canadian geese at the Swan Lake Wildlife Refuge, hunter visits, average cost per visit, geese population, and harvest levels, a stochastic programing model is presented. Following optimal policy, a long run equilibrium population of 45,000 and harvest of 15,000 are determined. Results imply that there is an economic justification for an increase in the annual harvest rate of Canadian geese. Evaluation of prospective investments in the wildlife resource requires an estimation of demand over time. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Waterfowl, economics, management.

460. Kilgore, Bruce Moody
1954. A comparison of editorial aspects of State fish and game and conservation department magazines. M.A. thesis, Univ. Okla. 140 p.

Study compares three or four issues from 40 game department magazines or bulletins from 37 States. Of the 40 publications, 23 are free of charge, while 17 charge from $0.40 to $3. Content classification indicated that editorial text averaged 70 percent (over half of the editorials related to management, harvest, and biological aspects of wildlife) with illustrations comprising nearly all the rest (29 percent) of the entire content. Using Flesch's formula for "readability" and "human interest" the *Alabama Conservation, Florida Wildlife,* and *Missouri Conservationist* top the list of 40. For "readability" 23 State publications rated "fairly difficult" to read while only one classed as "very easy." For "human interest," one publication rated "very interesting," 16 rated "interesting," 18 rated "mildly interesting," and 10 rated "dull." Only eight State publications received ratings "standard and better" for readability and "interesting or better" for human interest.

KEYWORDS: Literature, surveys.

461. Kimball, Thomas L.
1955. The application of controlled hunting to the take of big game. 45th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 45: 95-102.

Paper discusses factors involved in obtaining a proper game harvest: time, type, and length of season, bag limits, areas and range conditions that affect hunter distribution, weather, and publicity.

KEYWORDS: Colorado, management, harvest statistics.

462. ________ 1957. Pros and cons of nonresident fees. 47th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 47: 63-67.

State game and fish departments should be concerned about non-resident fees because they are important to game harvest and to financing management. Arguments favoring low non-resident fees are: (1) wildlife on Federal lands is owned by all people in the United States, (2) high fees tend to retard private economic activity and thus reduce tax revenue, and (3) non-resident hunters hunt more in the back country and thus harvest animals where residents seldom go. Arguments for high non-resident fees include: (1) wildlife belongs to people of the State, and they should get maximum returns for it, (2) competition between resident and non-resident hunters is reduced, and (3) if decreased fee stimulates more (visitor) economic activity, more also goes to game department. Most conflicts can be resolved by legislative measures except for antagonism between resident and non-resident hunters. Analysis of Colorado license revenue showed a 61.6-percent decrease in revenue after deer fees were reduced from $40 to $7.50 (resident fee) in order to get increased hunting for an adequate harvest of surplus deer.

KEYWORDS: Resident vs. nonresident, economics, user fee, Colorado, fishing.

463. ________ 1958. Keeping hunting and fishing privileges on and recreational access to the public lands in the east and the west. 48th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 48: 76-82.

The primary access problem is to public beaches, lakes, and streams surrounded by private lands, rather than to public lands for hunting. No major access problems were reported by 20 States, but 17 States have been denied the right of eminent domain (to acquire access to public lands).

KEYWORDS: Access, fishing, non-consumptive use, landowner-public.

464. ________ 1961. A place to hunt and fish. 41st Conf. West. Assoc. State Game Fish Comm. Proc. 41: 4-8.

Aggressive and positive attitudes must be developed in governmental agencies and among outdoor enthusiasts if the American hunting and fishing heritage is to be preserved. The picture is bleak for fulfilling the desires of the general public, because productive land is rapidly shrinking and access is frequently denied to public land. Wildlife management authority should remain with the State, not the Secretary of the Interior, for any new areas considered for park purposes.

KEYWORDS: Fishing, resource use, Federal-State jurisdiction.

465. ________ 1962. Where organized sportsmen fit into the over-all conservation picture. 16th Conf. Southeast. Assoc. Game Fish Comm. Proc. 16: 499-505.

Highlighted are contributions to conservation made by sportsmen's groups such as the Boone and Crockett Club, the American Wildfowlers, Ducks Unlimited, the American Game Association, and the National Wildlife Federation.

KEYWORDS: Conservation, clubs.

466. __________
1963a. For public recreation: Private development of hunting and fishing. J. Soil Water Conserv. 18(1): 49-53, illus.

Private land in the United States produces 80 percent of game taken by hunting and contains 85 percent of the wildlife habitat that is economically feasible to improve. Increasing population and decreasing work time means increasing recreation pressure. The continuation of public hunting and fishing will depend largely on the private landowner and whether or not he can be convinced that wildlife and hunting on his lands are beneficial to him and the general public. Increased aid, both technical and monetary, is needed from governmental agencies and the general public in order to convince the private landowner.

KEYWORDS: Farmer-sportsman relations, resource use, landowner-public, landowner-private.

467. __________
1963b. What is the National Wildlife Federation? Nat. Wildl. 1(6): 30-31, illus.

Questions and answers are presented covering the federation's goals, policies, membership, size, and budget considerations.

KEYWORDS: Clubs.

468. __________
1965. Farm harvest for hunters. Mich. Conserv. 35(5): 2-7, illus.

Article discusses the "cropland adjustment" section of the 1965 Food and Agriculture Act which, if passed, would provide for the Secretary of Agriculture to make payments to farmers who retire lands from active agriculture and turn them to recreational uses.

KEYWORDS: Economics, legislation.

469. King, Byron B.
1961. Use of public lands for hunting. 41st Conf. West. Assoc. State Game Fish Comm. Proc. 41: 46-51.

Army regulations concerning management and harvesting of fish and game resources on military reservations stipulate that hunting will be in accordance with the fish and game laws of the State. The military commander will control and maintain security, good community relations, and encourage recreation for military personnel. A brief history of the development of the big game hunting program at White Sands Missile Base is followed by a discussion of the relationship between State game conservationists and military personnel.

KEYWORDS: Management, New Mexico, landowner-public.

470. King, Frank H.
1948. The management of man. Wis. Conserv. Bull. 13(9): 9-11.

Rambling article identifies weaknesses still evident in wildlife management. Wildlife research results are not used; more public appreciation of research is needed; technical findings should be popularized; sportsmen and administrators see research results as impractical; and the public does not understand management programs, so will not accept them. Education

of landowners and managers is also needed. Sportsmen think wildlife management is production of something to shoot. Although the American idea of free wildlife and public hunting should be perpetuated, quality rather than quantity should be improved. The author stresses the importance of human factors of wildlife management and feels we must educate to legislate, with constant publications getting the "right" information to large numbers of people.

KEYWORDS: Public relations, profession, management.

471. King, Willis
1942. Trout management studies at Great Smoky Mountains National Park. J. Wildl. Manage. 6(2): 147-161, illus.

Creel census studies conducted on three streams in 1938, four in 1939, and five in 1940 reveal that legal trout catch per mile of open water varied from 146 to 1,167. Average catch of legal-sized trout per hour varied from 0.52 to 1.32. It is suggested that the rainbow size limit be lowered from 8 to 7 inches.

KEYWORDS: Fishing, Tennessee, management, harvest statistics.

472. Kirkpatrick, Thomas O.
1965. The economic and social values of hunting and fishing in New Mexico. Univ. of N.M., Bur. Bus. Res., 94 p., illus.

During May and June 1964, approximately 7,500 questionnaires were mailed to a random sample of resident and non-resident license holders. About 53-percent response was received. General findings were as follows. (1) The factors most influencing the volume of sales of licenses are climatological influences, existence of hunting and fishing facilities, license fees, expectations of sportsmen, and communications between and among sportsmen and State agencies. (2) A large increase in the number of licenses sold is expected to occur between 1964 and 1975 (from 250,000 in 1964 to an estimated 468,000 in 1975). (3) Eighty-one thousand children under 14 fished in New Mexico during 1964 and of this, 60,000 were children of resident fishing license holders. (4) In 1963, resident and non-resident license holders spent, excepting license fees, an estimated \$53.4 million (nonresidents spent \$9.7 million). (5) During 1963, an estimated 45,000 residents went to other States to hunt and fish and spent about \$6.9 million there. The reason most often given was that more fish and game could be obtained elsewhere. (6) The most fished county was Taos with 14.8 percent of all fishermen and second was San Miguel with 14.5 percent. Rio Arriba County ranked first with resident big game hunters and Colfax ranked first with nonresidents. Eddy County is first with resident bird hunters and Dona Ana is first with nonresidents. (7) In 1963, license holders spent approximately 3 million man-days hunting and fishing. (8) Of persons not renewing licenses, 3.1 percent of the holders of resident fishing licenses and 1.9 percent of the holders of non-resident fishing licenses gave as their reason a stronger interest in other forms of recreation. (9) Only 2 percent of all sportsmen fish or hunt alone while 90 percent are accompanied by one to four companions. Much information was also obtained regarding the socioeconomic characteristics of hunters and fishermen, the hunting and fishing unit, and behavior patterns (e.g., when persons hunt and fish, how many years they have hunted and fished). More facilities are needed.

KEYWORDS: Fishing, economics, benefits, preferences, New Mexico, resident vs. nonresident.

473. Klemm, Cyrille de
1972. The conservation of migratory animals through international law. Nat. Resour. J. 12(2): 271-277.

Migratory birds and anadromous fish can be considered the objects of successive ownership on the part of political subdivisions along their migration route. Joint ownership of exploited animal populations should have as its primary objective the establishment of management practices designed to secure the maximum sustainable yield. Early treaties between the United States and Canada do not provide for reserves or habitat preservation. In a 1936 treaty between the United States and Mexico, reserves are provided for, but there is no provision for joint commissions of advisement and enforcement.

KEYWORDS: Administration, legislation, refuge, conservation, historical value, Canada, Mexico.

474. Klessig, Lowell L.
1970. Hunting in Wisconsin: initiation, desertion, activity patterns, and attitudes as influenced by social class and residence. M.S. thesis, Univ. Wis., 152 p.

Data are given from: (1) Wisconsin Survey Research Laboratory's annual statewide interviews with a random sample of 574 adults including several questions about hunting among the 192 items on the interview schedule; (2) mailed questionnaires from 69 percent (1,015) of 1,472 resident hunters to whom it was sent. Initiation to and desertion from hunting are better indicated by rural-urban residence than by social class. Rural youth are highly associated with hunting because of accessibility to hunting areas. Social and psychological reasons accounted for two-thirds of the desertions. Only 30 percent of the hunters considered "bagging game" their most important motivation, implying the importance of appreciative rather than consumptive motives to hunter satisfaction. Six different types of hunting were defined: big game hunters (84 percent), upland bird hunters (58 percent), small mammal hunters (57 percent), waterfowl hunters (25 percent), big game archery hunters (21 percent), and predator hunters (18 percent). Big game hunters tend to be more from rural areas, are less educated, and travel farther than other hunters. Highly educated hunters are overrepresented in all types of hunting except big game hunting; they hunt a greater variety of game, spend more days and hours hunting, tend to travel more, and have more success. Rural hunters are overrepresented among big game hunters and predator hunters, and urban hunters tend to hunt birds. Public hunting grounds are the most popular hunting property, especially among the lower class and urban hunters who have difficulty obtaining access to private property. Leased or private club lands are not all popular. Only 12 percent usually hunt alone, and they tend to be from rural areas. Twenty-two percent of hunters belong to a conservation or sportsman's club. Intensive management was desired by educated hunters. Questions on ecological principles showed that 42 percent of the hunters did not believe doe deer should be harvested, 82 percent believed foxes should be controlled, and 70 percent favored bounties. The overwhelming majority support the right of landowners to prohibit hunting and one-third are willing to pay for hunting privileges. (References, 95. Thesis includes data and discussion on gun control legislation, violence on TV, and 24-page (including 16 references) appendix on a study "The Duck Hunter and Species Management.")

KEYWORDS: Wisconsin, preferences, characteristics.

475. Knapp, Jerome J.
1965. The urban sprawl and the hunter. Rod Gun Can. 66(12): 12-13, illus.

The decrease of available hunting land and the increase of hunters are being relieved by Provincial governments, private enterprise, and gun clubs. Hunters must exert influence to harmonize their sport with urbanization.

KEYWORDS: Canada, resource use.

476. Knott, Norman P.
1963. Free hunting versus fee hunting. 43d Conf. West. Assoc. State Game Fish Comm. Proc. 43: 92-97.

Article discusses attitudes about hunting on private land, human management problems of access, landowner relations with sportsmen, and the necessity of user fees.

KEYWORDS: Farmer-sportsman relations, user fee, landowner-private.

477. Koch, Elers
1941. Big game in Montana from early historical records. J. Wildl. Manage. 5(4): 357-370.

Article documents records of early explorers, trappers, and military personnel which yield information on game conditions throughout Montana beginning with the Lewis and Clark Expedition in 1804. The theory is rejected that the mountains were thinly populated with game until the white men came and drove elk and buffalo into the mountains through persistent hunting.

KEYWORDS: Historical value, Montana, literature.

478. Kohlsaat, H. H.
1924. The greatest game market in the world. Sat. Evening Post 196(43): 72.

Historical account of Chicago's game market prices and a dinner menu card are reported.

KEYWORDS: Economics, historical value, commercial hunting.

479. Kouba, Leonard J.
1972. Controlled shooting preserves: integrating recreation and sound land management. J. Soil Water Conserv. 27(4): 156-159, illus.

Commercial and public shooting preserves have emerged in the United States in response to increasing hunting demand. In 1970, 2,525 shooting preserves were operating. Basic legislation governing preserve shooting is similar in most States. Requirements include the release of pen-reared game, fixing a percentage of each species that may be shot, payment of a license fee, adequate posting and fencing of boundaries, and fixing duration of the shooting season. A preserve is usually established by an individual or group of sportsmen. Data are presented on the number of preserves in the various States from 1954 to 1970.

KEYWORDS: Plant and shoot, management.

480. Kozicky, Edward

1960. Does the department have a responsibility to provide access to private lands? S.D. Conserv. Dig. 27(4): 22-25, 34, illus.

Game departments cannot assure guest privileges for sportsmen on private land. This privilege is granted through personal hunter contact. An educational program for sportsmen and landowners is paramount in any game management program.

KEYWORDS: Farmer-sportsman relations, access, education, public relations.

481. Kozicky, Edward L.

1964. Private enterprise in outdoor recreation. J. Soil Water Conserv. 19(1): 57-60, illus.

Projection of increased leisure time for the future implies increased need for recreational facilities. The present public lands are inadequate; thus private enterprise found it necessary for providing future recreation facilities. Greater cooperation between public agencies, private enterprise, and the general public is needed for the study, establishment, acceptance, and continuation of quality private enterprise recreation. Game shooting preserves are used as examples.

KEYWORDS: Legislation, landowner-private, plant and shoot.

482. _________ and John Madson

1966. Shooting preserve management--the Nilo system, 312 p., illus. East Alton, Ill.: Conserv. Dep., Winchester West. Div., Olin Corp.

A private plant and shoot preserve is presented as a model. The text covers in detail a history of shooting preserves, types of preserves, management of hunters, habitat and four species of game birds, hunting dogs, economics of private preserve enterprises, promotion and public relations, hunting safety, and other management considerations.

KEYWORDS: Plant and shoot, management, safety, historical value, economics, commercial hunting, user fee, upland game birds, waterfowl.

483. Kranz, Marvin Wolf

1961. Pioneering in conservation: a history of the conservation movement in New York State, 1865-1903. Ph.D. diss., Syracuse Univ., 634 p.

New York has done more than any other State to preserve wilderness. It was the first State to set aside forest acreage and among the earliest to begin the replenishment of fishery resources. The acquisition of Niagara Falls in 1885 was a first step in park system expansion. The game restoration program restored deer in all parts of the State by 1920, but more influential was the forest conservation movement. State legislation in 1885 enacted forest statutes which created the State preserve, the appointment of a forest commission, and the adoption of fire prevention measures. Wilderness lovers saw that the timber on State-owned Adirondack and Catskill lands was made inviolate. Professional foresters generally oppose the preserve concept and have contended that supervised lumbering would be more beneficial. Agitation over the forest preserve policy has dominated the conservation picture in New York and has overshadowed important developments in forest plantations, industrial forestry, and the enlargement of recreational facilities. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: New York, conservation, legislation, refuge, historical value.

484. Krause, Gary F., Frank W. Sampson, and J. Martin Orr
1969. Biased coyote harvest estimates: a paradox. J. Wildl. Manage. 33(2): 444-446.

The reported coyote hunting effort and kill in Missouri is biased because much coyote kill is incidental to other hunting. Some hunters report hunting coyotes only if they kill one. Unsuccessful hunters are underestimated. Consequently the statewide harvest appears highly biased compared with county bounty-census data.

KEYWORDS: Research needs, predator, Missouri.

485. Kruger, Theodore
1929. Are we drifting into European systems of game management? J. For. 27(3): 262-263.

Private land and State forest hunting systems in Prussia are briefly summarized and contrasted with the American system.

KEYWORDS: Germany, management, landowner-private.

486. Krukewitt, Charles W.
1966. A system for charging entrance fees at Crab Orchard National Wildlife Refuge in accordance with the Land and Water Conservation Fund Act of 1965. M.S. thesis, South Ill. Univ., 80 p.

Objective was to determine an efficient system for collecting fees to realize maximum revenue, good public relations, optimum recreation, and to predict effects of fee on management. Details are presented on Land and Water Conservation Fund Act of 1965, history since its inception, advantages and disadvantages, and its application to proposed fees at Crab Orchard. An interview survey on the 44,000-acre refuge which catered to almost 2 million boaters, campers, hunters, fishermen, swimmers, picnickers, and sightseers during 1966 shows that swimming was the major use. Over half the users spent more than $10 and about one-quarter spent more than $20 during each visit to the refuge. A decrease in recreation use is predicted as result of entrance fees. (Hunting, a major refuge use, was not reflected in figures.)

KEYWORDS: Fishing, public relations, refuge, user fee, historical value.

487. Krutch, Joseph Wood, and Harold E. Anthony
1957. The sportsman or the predator? Part I. "A damnable pleasure." Part II. "But it's instinctive!" Sat. Rev. Lit. 40: 8-10, 39, 40.

A debate is presented between opponent and proponent of hunting which articulates premises underlying opposition to and defense of hunting on a moral-philosophical level. Krutch views wanton killing for sport as a damnable evil, describes the sportsman's motive, chides the idea of sporting chance or killing according to gentlemanly rules, and concludes that hunters have no vivid sense of killing: "Birds are simply livelier, less predictable clay pigeons." Anthony endorses much of Krutch's thesis but sees wanton killing as reprehensible to the principles of American sportsmen. He describes qualification for a true sportsman and asserts that man is a predator, biologically and historically. A sportsman shoots because it enriches life for him, not for the benefit of deer. "Sportsman" is not a synonym for "hunter." Sportsman values gained in hunting are not necessarily the kill, but rather courage, hardihood, self-confidence, and a sense of fair play as exemplified in switching from guns to camera.

KEYWORDS: Philosophy, antihunting.

488. Kuluvar, H. Lee
1954. Man or deer? Field Stream 59(6): 43-45, 98, illus.

Using a device developed by the Army and Navy in World War II to train men to spot planes and ships, the author has developed a similar training program for hunters. His tachistoscope illustrates how easy it is to mistake a man for a deer and provides visual training for hunters before they enter the woods.

KEYWORDS: Safety, education.

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489. Lacaillade, Harold C., Jr.
1968. New Hampshire hunter preference survey 1964. N. H. Fish Game Dep. Tech. Circ. No. 22a, 18 p., illus.

A return of 70 percent was obtained after two questionnaire mailings to 3,183 hunters. Resident and non-resident hunter numbers are increasing and their game preferences in descending order were big game, game birds, small game, and non-game animals. Data are given on the number of hunters seeking various game species and hunter income and expenditures.

KEYWORDS: New Hampshire, preferences, resident vs. nonresident, fishing, upland game birds, waterfowl, small game, big game.

490. Lambou, Victor W.
1961. Determination of fishing pressure from fishermen or party counts with a discussion of sampling problems. 15th Conf. Southeast. Assoc. Game Fish Comm. Proc. 15: 380-401, illus.

The fisherman count method of determining fishing pressure is described, and some sampling problems are discussed, including distribution, bias, and variance of a product. Mathematical formulas and graphs are predominant.

KEYWORDS: Crowding, research methods, fishing.

491. Langlois, T. H.
1944. The role of legal restrictions in fish management. 9th Conf. North Am. Wildl. Trans. 9: 197-202.

Fishing laws directed by an interest in people rather than in fishes spring from three basic concepts of human nature: the spirit of individual willingness to do without something that is available and wanted, the wish of some people to control the behavior of others who are less willing to do without the same thing, and the cultural concept of protecting the females and young. Any hope for improving fishing lies in the ability to help the environment meet the needs of the fishes. Laws which regulate fishing and cost much to enforce aim to secure financial support for administration. Laws which affect fish welfare are also summarized. Repealing legislative restrictions and discontinuing the enforcement program would permit the use of more funds for the more positive procedure of habitat improvement.

KEYWORDS: Fishing, management, legislation.

492. Lanier, James W., III
1951. The attitudes of landowners in Alachua County, Florida, concerning sportsmen and cooperative hunting plans. M.S. thesis, Univ. Fla., 61 p.

Landowners included in the study demonstrated a favorable attitude towards sportsmen. It was hypothesized that this relationship could be improved by a greater consideration of landowners' rights by sportsmen. Seventy-three percent of the total farmland area has been posted by landowners in this county, mainly to protect livestock. A favorable attitude exists concerning cooperative hunting plans on the part of both white and colored landowners. Although few landowners have heard about these plans, there is indication that such plans could operate satisfactorily in Alachua County. (Thesis restricted to University of Florida use.)

KEYWORDS: Farmer-sportsman relations, Florida, landowner-private, preferences.

493. Larson, Joseph S.
1959. Straight answers about posted land. 24th Conf. North Am. Wildl. Trans. 24: 480-487, illus.

During 1956 a mail questionnaire survey of 1,165 Massachusetts landowners was made to determine the amount of land posted against hunting and the main reasons for the posting. A minimum of 41 percent of Massachusetts land is closed to sportsmen, although 59 percent of the landowners who post their land permit hunting and fishing. The two main reasons listed for posting were destruction of property and discharge of firearms close to buildings.

KEYWORDS: Access, landowner-private, Massachusetts.

494. Latham, Roger M.
1949. The sportsman--bottleneck to better hunting and fishing. Wis. Conserv. Bull. 14(12): 3-7, illus.

Considerable pressure is exerted upon State conservation departments by sportsmen's clubs, resulting in change from scientific to non-scientific game and fish management. Hunters and fishermen who are not trained in wildlife fields are unqualified to criticize or suggest. Many of the most severe critics of conservation department work and policies are the most flagrant violators of the game and fish laws. In Pennsylvania hunters still fight every declared doe season and the pressure of their legal action has caused the suspension of several proposed doe seasons. In the East, sportsmen are still forcing the game departments to import cottontail rabbits from Missouri for release, although research has shown that the survival is low and that the native stock is more than adequate. These two examples illustrate the distrust that hunters and fishermen have for the wildlife profession. Organized groups of sportsmen can fight against anticonservation legislation, pollution, the exploitation of wildlife, and other endangering influences. They should fight for restoration of habitat, free public hunting, etc.

KEYWORDS: Education, profession, fishing, either-sex hunt, clubs.

495. _________ and Devereux Butcher
1963. Why I hunt. Why I do not hunt. Nat. Wildl. 1(5): 14-15, illus.

Two opinions about hunting are contrasted: hunting is a wholesome form of outdoor recreation, and it is morally wrong to kill wildlife for "sport."

KEYWORDS: Philosophy, antihunting.

496. Lauckhart, J. Burton
1970. Falconry management in Washington. 50th Conf. West. Assoc. State Game Fish Comm. Proc. 50: 1-4.

Falconers in Washington are expected to exceed 300 in 1970 and they are allowed to take one wild hawk per year. In 1969 falconers reported taking 97 hawks. A system of registration for all legally held peregrine and prairie falcons is needed to help apprehend those who take birds illegally.

KEYWORDS: Falconry, Washington, management.

497. Lay, Daniel W.
1946. Controlled antelope hunts and some problems of administering public hunting. 11th Conf. North Am. Wildl. Trans. 11: 274-279.

A discussion is given of regulated antelope hunts in 1944 and 1945. Hunt planning, supervision, fees, public response, and criticisms are included. Antelope hunting cannot be provided for everyone, but high standards and a high degree of success should be maintained for those who do hold licenses.

KEYWORDS: Texas, big game, management.

498. Laycock, George
1961. Bums in the bulrushes. Sports Illus. 15(17): 64-66, illus.

A spying biologist found that duck hunters who claimed to be good sports were often liars and cheats. For 24 days he observed one of the 28 duck blinds on an Ohio marsh. Hunters were assigned to the blind by lottery and each day a new pair occupied the blind. The biologist took notes on hunter activities which he later compared with checking station information provided by the same hunters. The biologist counted a total of 839 shots fired from one blind, but the hunters reported only 449 shots. In 24 days the blind's occupants bagged 53 birds. Thirty-one of these were shot on the water by 12 of the hunter teams, but only five teams admitted to shooting any bird on the water. Fourteen teams reported crippling 27 ducks, but the biologist counted 67 crippled birds. Biologists customarily set crippling loss at 30 percent of the bag, but in this case crippling loss was 126 percent. Hunters seem to be biased in reporting, not from fear of punishment, since half of the hunters from the one blind did not break any law, but because of pride. Sky-busting and shooting sitting ducks are not acceptable sporting techniques. It is suggested that other States plant spies in their marshes to determine bias in hunter reporting.

KEYWORDS: Waterfowl, management, enforcement, research methods, law violation.

499. Lazan, Gil
1969. The thrill killers. Am. For. 75(5): 6, 7, 36, illus.

Snowmobile trails built by clubs on Forest Service land in northern Minnesota provided access to food for hundreds of deer during a record snowfall winter. During 3 weeks, 45 deer were run down and shot by "renegade snowmobilers." After the Forest Service threatened to close trails if killings continued, outraged sportsmen and snowmobilers across the Nation formed a $1,000 cash reward for information leading to the arrest and conviction of snowmobilers wantonly and maliciously destroying game anywhere in the United States.

KEYWORDS: Enforcement, big game, Minnesota, law violation.

500. Leedy, Daniel L.
1949. Hunting statistics in the United States, 1936 vs. 1946. 14th Conf. North Am. Wildl. Trans. 14: 410-423.

Statistics were compiled largely through questionnaires submitted by 39 State game departments, supplemented by published reports and personal interviews. Comparisons were made of the game status, game kill, and number of hunters and licenses issued for 1936 and 1946. Statistics are still inadequate and annual nationwide compilations of data on small game are needed. In the fiscal year 1947, 76 percent more licenses were sold, yielding a 151-percent increase in revenue over the 1936 license sales. A higher percentage of the total number of hunters have purchased licenses

in recent years. Three-fourths of the total amount spent in harvesting the game crop went for small game hunting. The comparative kill of 24 game species in 1936 and 1946 is listed and supplementary data on waterfowl and furbearers are included. The abundance and distribution of game influence not only the amount of hunting but also the hunter's preference of game species.

KEYWORDS: User fee, economics, harvest statistics, surveys.

501. Leffler, Ross L.
1941. The hunting accident problem: what shall we do about it? 35th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 35: 122-133.

Firearms and ammunition manufacturers should campaign to overcome public opposition to hunting, and civic organizations should initiate firearm safety programs.

KEYWORDS: Pennsylvania, safety, education.

502. ________
1958. Public hunting on Federal refuges--a positive policy. 48th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 48: 143-146.

Acquisition of key wetlands is basic to preservation of waterfowl populations.

KEYWORDS: Administration, waterfowl, refuge.

503. Legler, Eugene, Jr.
1967. Sampling to determine unreported deer kill in Tennessee, 1964-1966. 21st Conf. Southeast. Assoc. Game Fish Comm. Proc. 21: 69-73.

A method is described by which the unreported open deer kill in Tennessee has been estimated. A comparison of results from interviews of nonrespondents, and use of the computer extrapolation method failed to reveal important or consistent differences between the two methods.

KEYWORDS: Harvest statistics, Tennessee, big game, research methods.

504. Leipheimer, E. G., Jr.
1965. Wildlife management and the recreation program in the state of Montana. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 50-54.

Montana's statewide outdoor recreation plan is discussed and, in particular, the administration of a regulated hunt to reduce the elk herd.

KEYWORDS: Montana, management, big game, non-consumptive use.

505. Lennon, Robert E., and Phillip S. Parker
1961. The fishing-for-fun program on trout streams in Great Smoky Mountains National Park. Soc. Am. For. Proc., p. 106-112, illus.

Sport fishing for wild trout can be preserved, improved in quality, and made available to increasing numbers of anglers by prohibiting the kill of trout under the Hazzard Plan of catch and release. Proportionately more tourists fished the fishing-for-fun streams than other Park streams, and they consistently enjoyed a greater measure of success.

KEYWORDS: Fishing, non-consumptive use, North Carolina.

506. Leonard, Justin W.

1949. Research man vs. administrator--the research man's viewpoint. J. Wildl. Manage. 13(3): 237-244.

In the research man's eyes, the greatest sins the administrator can commit include: directing investigators to find facts to support a personal hunch, suppressing research findings that run counter to established policy, demanding that conclusions be released before the data have been sufficiently rechecked, diverting significant portions of research budgets to programs of routine management character, awarding policy-forming positions to businesslike but unqualified laymen, publishing reports under the name of the department or agency chief or not giving the researcher ready access to publish his findings, and failing to hold competent research men in the conservation field who are attracted to less productive but more gainful jobs.

KEYWORDS: Administration, research needs, profession.

507. ________

1965. Moral, ethical and fiscal aspects of wildlife management. 30th Conf. North. Am. Wildl. Nat. Resour. Trans. 30: 422-425.

Hunting and fishing are socially acceptable pursuits, threatened less by moral misgivings than by lack of space. Maintenance of the resource is an economic matter. Examples of cooperation among sportsmen, recreationists, and wildlife managers are cited; but the fact that non-consumptive uses of space and facilities are growing proportionately faster than hunting and fishing poses new problems for the manager. All outdoor users must accept the responsibility to maintain ecological integrity and quality while the wildlife manager embraces enough of the varieties and orientations of outdoor resource users for him to communicate effectively with both users and the new breed of decisionmakers.

KEYWORDS: Fishing, philosophy, economics, non-consumptive use, resource use.

508. Leopold, A. Starker, Clarence Cottam, Ian McT. Cowan, Ira N. Gabrielson, and Thomas L. Kimball

1968. The national wildlife refuge system. 33d Conf. North Am. Wildl. Nat. Resour. Trans. 33: 30-54.

Article appraises the significance of the national refuges in migratory bird conservation and comments on management practices. In managing refuge units for their primary objectives the broadest spectrum of wildlife values must be purposefully guarded and restored. A broad philosophical perspective on all aspects of wildlife is presented.

KEYWORDS: Conservation, management, refuge, philosophy, waterfowl.

509. Leopold, Aldo

1918. Forestry and game conservation. J. For. 16(4): 404-411.

The game resources of the National Forests are as depleted as they were 10 years ago when the National Forests were established. Dual authority, local opposition, and failure to employ the principle of highest use are three reasons for lack of an aggressive game policy. That foresters can meet the needs of the game problem by simply applying the forest principles with which they are familiar is argued by an analogy between the sciences of game management and forestry. Comparison is also made between forestry and game management in selection of species.

KEYWORDS: Administration, historical value, management.

510. ________
1919. The National Forests: the last free hunting grounds of the Nation. J. For. 17(2): 150-153.

Demand for hunting on the National Forests will increase not only with increases in population and transportation, but with the rising price of hunting as exemplified by commercialization of hunting privileges called "game farming." Some lessons in National Forest game policy are contained in this forecast: the Nation's last free hunting ground must be developed and perpetuated; the Forest Service must retain its policy of keeping out exclusive privilege; a non-resident license surtax is not only justice, but common sense; the National Forest hunter will constitute an increasing forest hazard; where game interferes with livestock, hunting demand must be considered when applying the principle of highest use; lastly, it will be good business for the Forest Service to develop species on which it has a practical monopoly.

KEYWORDS: User fee, economics, historical value.

511. ________
1926. The way of the waterfowl. Am. For. 32(389): 287-291, illus.

Article describes how the Anthony Bill will help ducks and duck hunting. It is an example of New Mexico's refuge system in actual operation.

KEYWORDS: New Mexico, waterfowl, refuge, legislation.

512. ________
1929. Report of the committee on American wild life policy. 16th Conf. Am. Game Trans. 16: 196-210.

This report calls for increasing game populations for recreational use. Since control of hunters is legislatively well developed, the present problem is to get environmental controls for game. It is concluded that the following defects are common to the whole game program: The program is too small and does not meet the needs of the existing human population; its leadership does not understand that the public can best get farm game by making it profitable for the farmer to provide for game; and many game management practices are faulty. The program needs trained leaders, workers, and researchers; it needs better public education and organization of its State conservation departments; and finally, Federal and State financing is needed. (Reissued; see Wildlife Management Institute 1971b.)

KEYWORDS: Management, conservation, administration, profession, farmer-sportsman relations.

513. ________
1930a. The American game policy in a nutshell. 17th Conf. Am. Game Trans. 17: 281-283.

Stressing the need for a game policy, Leopold points out that the only new thing in the proposed game policy is that "we quit arguing over abstract ideas, and instead go out and try them." The ideas which served to maintain the virgin game supply seem to have reached the limit of effectiveness. The proposed game policy is an admission that things are not as they should be according to Leopold, and that sportsmen are not the only group concerned with game conservation. The landowners and protectionists are also very concerned. Leopold points out that wildlife proponents are on the defensive,

but their critics are no more reasonable even if they do have the public ear. (Reissued; see Wildlife Management Institute 1971b.)

KEYWORDS: Administration, resource use.

514. ________
1930b. Report to the American Game Conference on an American game policy. 17th Conf. Am. Game Trans. 17: 284-309.

Game management programs cannot command the good will or funds necessary for success without harmonious cooperation between sportsmen and other conservationists. Sportsmen must recognize conservation as one integral whole, of which game restoration is only part. The wild game crop is the result of the breeding habits of the species, the environment in which it lives, and the environment is the only area open for modification for eventual betterment of populations. Species can be classified into four classes: farm game, forest and range game, wilderness game, and migratory game. Management plans of several States are presented. (Reissued; see Wildlife Management Institute 1971b.)

KEYWORDS: Big game, management, conservation, administration, small game, waterfowl, upland game birds.

515. ________
1933a. Game management. 481 p., illus. New York: Chas. Scribner's Sons.

Leopold defines game management as "the art of making land produce sustained annual crops of wild game for recreational use." The vision of the professional forester is employed in tracing the developments of game management. Parts I and II include the history of ideas in game management, game biology and habitat management. Part III is devoted to "Game Economics and Aesthetics," "Game Policy and Administration," and "Game as a Profession." (Condensed from book review by C. E. Rachford in *Journal of Forestry* 31(6): 700-701.)

KEYWORDS: Management, profession, historical value, economics, administration.

516. ________
1933b. The conservation ethic. J. For. 31(6): 634-643.

The gradual extension of ethical criteria to economic relationships is an historical fact. Economic criteria did not suffice to adjust men to society; they do not now suffice to adjust society to its environment. If our present evolutionary impetus is an upward one, it is ecologically probable that ethics will eventually be extended to land. The present conservation movement may constitute the beginnings of such an extension. This may radically modify what now appears as insuperable economic obstacles to better land use.

KEYWORDS: Philosophy, economics, historical value, resource use, conservation.

517. ________
1936a. Deer and Dauerwald in Germany. Part I. History. J. For. 34(4): 366-375, illus.

In Germany a plain case of mutual interference between game and forestry flatly contradicts the uncritical American assumption that the practice of forestry always promotes the welfare of wildlife. Article follows for nine centuries the slow but inexorable growth of a system of silviculture

incompatible with natural and healthy game and of a system of game management incompatible with a natural and healthy silviculture.

KEYWORDS: Big game, Germany, historical value, management.

518. ________ 1936b. Deer and Dauerwald in Germany. Part II. Ecology and policy. J. For. 34(5): 460-466.

Specific amendments of American practices that are indicated by German experience are: that a generous proportion of each forest be devoted entirely to floral and faunal conservation; that there are few American deer ranges where the total removal of deer predators seems justifiable or necessary; that there be respect for natural mixtures of large pine blocks; that concerted effort be given to the problem of dual jurisdictions over game; and that there be a generous policy in building carrying capacity while deemphasizing the building of animal herds.

KEYWORDS: Fishing, big game, Germany, management, non-consumptive use.

519. ________ 1937. The research program. 2d Conf. North Am. Wildl. Trans. 2: 104-107.

Research in the New Deal era was too small, appropriations were misdirected, programs were lopsided, and farm game was stressed while waterfowl, rare species, fish, songbirds, and wildflowers were neglected. Research methods were changing; it is clear that observational studies seldom yield enough information to guide policy. Professional education was inflated; it was turning out mediocre training without a research or ecological base. Vocational and non-professional education were also neglected.

KEYWORDS: Education, administration, historical value, research methods.

520. ________ 1939a. Academic and professional training in wildlife work. J. Wildl. Manage. 3(2): 156-161.

The committee on professional standards of the Wildlife Society defines what constitutes adequate training for the profession. The student (what he is, what he knows, what he can do, and how he thinks) is considered both at the time of selecting an undergraduate major and at the completion of his professional training. Equipment and requirements in professional schools are discussed.

KEYWORDS: Education, profession, historical value.

521. ________ 1939b. The farmer as a conservationist. Am. For. 45(6): 295-299, 316, 323, illus.

The pattern of the rural landscape should have a wholeness that guarantees paid conservation dividends. Land must be devoted to woods, marsh, pond, or just scenery to meet economic or semieconomic needs and to make the picture complete.

KEYWORDS: Landowner-private, conservation, esthetics.

522. ________ 1940a. History of the Riley Game Cooperative, 1931-1939. J. Wildl. Manage. 4(3): 291-302, illus.

The Riley Game Cooperative is a farmer-sportsman shooting preserve where farmers furnish land, townspeople furnish cash, and both contribute labor and share in the shooting. The Cooperative provides area for University wildlife study. Seasonal kill on 1,700 acres is 75 pheasants. Leg banding shows that wild birds comprise most of the kill, even though the restocking program comprises the bulk of the cost of providing pheasants. Cost per bagged bird is $1.40.

KEYWORDS: Management, refuge, landowner-private, upland game birds.

523. ________ 1940b. The state of the profession. J. Wildl. Manage. 4(3): 343-346.

This "state of the art" address was given by the president of the Wildlife Society with many insights still relevant today. The Wildlife Society may be helping to write a new definition of science by extending it beyond the creation and exercise of power to include the creation and exercise of wonder. The good life does not flow automatically from the good invention. The profession's job is one of mediating the increasing kit of scientific tools and their increasingly reckless application to shrinking biotas. Weak points in the profession are: the low proportion of private employment, lack of respect for private property by the public, too much superficial research aimed at quick returns, not enough non-economic research, too little attention by researchers to the history of wildlife, and lack of organized extension services.

KEYWORDS: Profession, historical value, research needs, philosophy.

524. ________ 1943. Wildlife in American culture. J. Wildl. Manage. 7(1): 1-6.

The culture of primitive people is often based on wildlife. Even civilized culture retains part of its primitive character. There is immeasurable value in any experiences which remind us of our distinctive natural origins and evolution and of our dependence on the soil-plant-animal-man food chain. Man needs to realize the extension of his system of ethics from the man-man relation to the man-earth relation. Excessive use of gadgets and "where-to-go" services are examples of mechanization that offers no cultural substitute for the values they destroy. Wildlife pleasure is better reaped by modern mentality than by modern machinery.

KEYWORDS: Historical value, philosophy, conservation, benefits, non-consumptive use, tradition.

525. ________ 1947. The ecological conscience. Garden Club Am. Bull. 11(4): 45-53.

The practice of conservation must spring from a conviction of what is ethically right, as well as what is economically expedient.

KEYWORDS: Philosophy, conservation.

526. ________ 1948. Why and how research? 13th Conf. North Am. Wildl. Trans. 13: 44-48.

Much confusion about wildlife research arises from a false premise about its purpose, which should be: to develop and expand an understanding of the biotic drama. Game researchers must start over and dig deeper. It

is futile to attempt practical research in advance of fundamental research because premature practicality ends in a blind alley.

KEYWORDS: Research needs, profession.

527. Lewis, Harrison F.
1930. The cash value of the wild life of Canada. 22d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 22: 79-82.

A summary is made of the dollar value of such items as fur, game fish, mammals, birds, sporting goods products, fishing tackle and equipment, sports clothing, nature photography, natural history magazines, transportation, accommodations, guides, liquor, recreational equipment, gas, and clubs.

KEYWORDS: Economics, Canada, fishing, benefits.

528. ________
1950. Wildlife values. Am. For. 56(4): 20-21, 33-34, illus.

Subject is how the economic or esthetic evaluation of wildlife affects its management. Wildlife often has conflicting values--positive values to some but negative values to others.

KEYWORDS: Management, esthetics, economics, non-consumptive use, benefits.

529. ________
1951. Wildlife in today's economy: aesthetic and recreational values of wildlife. 16th Conf. North Am. Wildl. Trans. 16: 13-16.

The meaning and success of life are dependent on a conscious or unconscious scale of values. Economic values are the kind by means of which people make a living. Esthetic and recreational values, primarily concerned with living a life, take no second place to economic values. Esthetic values relate to beauty and the capacity to enjoy it, while recreational values stress personal activity and participation. Recreational pursuits take the individual directly to the wildlife environment where public controls must be supplemented by intelligent self-restraint. Hunters, anglers, and photographers may be subdivided into many groups; yet all the values obtained may be reduced to two principal categories: personal pleasure and heightened ability to see environment with understanding.

KEYWORDS: Esthetics, economics, philosophy, non-consumptive use, benefits.

530. ________
1952. The role of certain treaties in wildlife management. 42d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 42: 143-149.

Paper covers management aspects of Canadian treaties with Canadian Indians, U.S. treaties with U.S. Indians, the U.S.-Canada migratory bird treaty, and the U.S.-Mexico convention for the protection of migratory birds and game mammals.

KEYWORDS: Canada, legislation, waterfowl, native claims.

531. ________
1966. Why's and wherefore's of the migratory bird regulations. Rod Gun Can. 67(6): 13-14, illus.

Article gives objectives and explanatory comments on the regulation of Indian and Eskimo rights, shooting restrictions, and the importance of research

KEYWORDS: Management, Canada, research needs, waterfowl, native claims.

532. Lewis, John Hammond

1948. Extension education in the wildlife conservation field. M.S. thesis, Oreg. State Coll., 106 p., illus.

National survey of State agricultural extension service and fish and game departments included 186 questionnaires and 238 letters (96-percent response) to assess wildlife extension education to develop program for Oregon. Findings show 90 percent of the State wildlife agencies average 4.3 percent of the operating budget on public education, seven states spend no money, and four States sent no report. Thirty States publish a game agency periodical reaching about one in 75 U.S. families. Programs of all States are evaluated; only 20 percent rated adequate in public conservation programs. Extension program for Oregon is proposed. (References, 34.)

KEYWORDS: Education, Oregon, surveys.

533. Lewis, Orville W.

1959. Are fish and game regulations too complicated. 39th Conf. West. Assoc. State Game Fish Comm. Proc. 39: 417-419.

Regulations are complicated, often unnecessarily, because wildlife administration is biologically difficult and influenced by public opinion.

KEYWORDS: Management, administration, Montana.

534. Ley, Ronald

1967. Why anglers really angle. Field Stream 71(10): 63, 109-110, illus.

Why do fishermen really fish? It is not because of hunger, except in the uncivilized wilderness. Sports fishermen are less interested in the fish for eating than in its pursuit. Fishing provides the rationale for escape from the press of people, business, and cares of the world and brings the fisherman close to nature in the outdoors. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Preferences, fishing, benefits.

535. Liguori, Victor Armand

1968. Stability and change in the social structure of Atlantic Coast commercial fisheries. Ph.D. diss., Princeton Univ., 382 p.

A comparative analysis was made of stability and change in the social structure of three contiguous fishing ports in one county in southern New Jersey. An historical and crosscultural perspective serves as a focal point for a more generalized analysis of order, ethnic composition, and change in the structure of a commercial fisheries society. Several generalizations are offered. The step from microscopic considerations to macroscopic analyses of organizational structure brings the reader to reflect on some important aspects of the viability of social systems. In recent years, many of the tensions intrinsic to the fishing industry have so significantly exceeded their boundaries that the very survival of commercial fishing in the United States has come into serious doubt. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: New Jersey, fishing, historical value.

536. Lime, David W.

1971. Factors influencing campground use in the Superior National Forest of Minnesota. USDA For. Serv. Res. Pap. NC-60, 18 p., illus. North Cent. For. & Range Exp. Stn., St. Paul, Minn.

To identify factors which influenced the distribution of visitors among auto campgrounds of the Superior National Forest, 248 campers were interviewed. Fishing was the element of the natural environment which campers reported most often as the reason why they chose this campground rather than some other campground in the National Forest.

KEYWORDS: Fishing, Minnesota, preferences, landowner-public.

537. _________ and Charles T. Cushwa

1969. Wildlife esthetics and auto campers in the Superior National Forest. USDA For. Serv. Res. Pap. NC-32, 8 p., illus. North Central For. & Range Exp. Stn., St. Paul, Minn.

Interviews with 248 auto campers in 31 campgrounds determined why people come to the National Forest, where they come from, how many observed wildlife, and whether seeing wildlife adds to or detracts from their experience and why. Study revealed 49 different reasons for visiting the National Forest. Fishing and wilderness headed the list, but wildlife was not a prime motivating factor even though 90 percent of those questioned had seen wildlife. Most regarded seeing wildlife as a supplementary attraction because they "enjoyed watching them," it was "educational for the youngsters," and added to the "close to nature" feeling. Authors suggest that wildlife and conservation education in the public schools along with land managers' participation on the ground "would substantially increase the esthetic importance of the wildlife resource to the recreationists." (References cited, 8.)

KEYWORDS: Non-consumptive use, esthetics, education, conservation, preferences.

538. Lincoln, Alexander, Jr.

1964. An endless conflict: the hunter and the landowner. Am. For. 70(8): 40.

Article reviews landowner and hunter rights and suggests that appropriate payments be made to the landowners.

KEYWORDS: Farmer-sportsman relations, management, New Hampshire.

539. Lincoln, Frederick C.

1944. Duck hunting vs. duck shooting. Am. For. 50(10): 481-483, 504-506, illus.

Article criticizes the practice of unsportsmanlike duck "shooting" and traces its development to a decrease in habitat and an increase in waterfowl hunters.

KEYWORDS: Waterfowl, refuge, philosophy.

540. Linduska, J.P.

1964. Game never had it so good. Wis. Conserv. Bull. 29(3): 26.

Without habitat which hunters are providing, many species could be "protected" to vanishing levels by the indifference that comes to the nonhunted.

KEYWORDS: Conservation.

541. Lipscomb, Louis W.
1943. Procurement of ammunition for other than military purposes. 8th Conf. North Am. Wildl. Trans. 8: 73-77.

Paper discusses the supply and distribution of ammunition available for various types of hunting guns.

KEYWORDS: Equipment, historical value.

542. Lister, C. B.
1941. Hunting accidents--what shall we do about them? 35th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 35: 115-122.

Hunting accident prevention includes showing the public that shooting is a safe sport, improving accident statistics, and an intelligent education campaign based on research.

KEYWORDS: Safety, education, public relations.

543. __________
1945. Hunting accidents. 10th Conf. North Am. Wildl. Trans. 10: 62-65.

The seriousness of the hunting accident problem cannot be determined until there is a uniform system for collecting, compiling, and disseminating data. A suggested uniform report for hunting accidents would obtain the facts that are necessary to protect the hunter from antigun and antihunting laws.

KEYWORDS: Safety, management, historical value, antihunting.

544. Lively, Charles E.
1953. The social side of conservation - some reflections on the conservation movement. 18th Conf. North Am. Wildl. Trans. 18: 36-43.

The conservation movement has failed to become popular because its concept has never been adequately understood by the masses, especially by those who should be most concerned. People have been insufficiently motivated to do anything very effective about the situation. Groups and clubs must be involved emotionally and intellectually in the process of sound resource management.

KEYWORDS: Conservation, education, clubs.

545. Lobdell, Charles Henry
1967. Socio-economic characteristics of Maine sportsmen. M.S. thesis, Univ. Maine, 95 p.

Mail questionnaires concerning personal characteristics sent to 1,500 (0.5 percent) licensed sportsmen (also sent to hunters in five New England States) and a separate questionnaire concerning sport preferences to 1,000 Maine sportsmen yielded 85.1-percent and 84.7-percent returns, respectively, after three followup letters. Maine sportsmen were typically male, 20 to 60 years old, married, only high school graduates, and rural-raised. They had hunted and fished before age 16 and had incomes over $5,000 per year. Their age, income, residence during youth, childhood experience, sporting club affiliation, occupation, and education were significantly related to preference for sporting alternatives. Late respondents had lower occupation levels, less education, and hunted and fished less than early respondents. Nonresidents reported more education, higher occupational levels, and higher

incomes. More trips for big game were made by hunters who had at least one of the following characteristics: a resident of Main, under 30 years old, rural-raised, or no education beyond high school. Small game was hunted most frequently by hunters who had either hunted prior to 16 years of age, belonged to a sporting club, had a vacation in 1965, or had graduated from college. Non-resident hunters participated more frequently in small game hunting than resident small game hunters. Those fishermen who fished for salmon and trout most frequently were either Maine residents, had fished prior to 16 years of age, or had only high school education. (Literature cited, 27.)

KEYWORDS: Fishing, Maine, characteristics.

546. Locke, S. B.
1938. The role of anglers, organizations, bait dealers, land owners, government and commercial fishermen in a program of fish management. 3d Conf. North Am. Wildl. Trans. 3: 305-306.

Brief paragraphs summarize the responsibilities of each group mentioned in the title. Generally, successful management needs public support, and such support depends largely on an understanding of the primary principles and objectives of the management. There is also personal satisfaction and enhanced enjoyment of the sport when individuals know what is being done and why.

KEYWORDS: Management, education, fishing.

547. Long, James F., Jr.
1968. Recreational development of Alabama public fishing lakes. M.S. thesis, Auburn Univ., 99 p., illus.

Study is an interview of 19 area managers and 191 users at 19 lakes managed by the Alabama Department of Conservation. Lake users were 88-percent male, averaged 47 years old, with 26 years of fishing experience, 59 percent traveled an average distance of 18 miles to reach the lake, and 81 percent said they spent 5 hours or more per trip. Seventy-two percent of users felt the fishing was average or better, but 60 percent said "existing facilities and services were not adequate." Lake managers were asked to rank their area as "adequate, inadequate," or "needed, not needed" for 19 activities Managers typically termed concessions as inadequate but fishing as adequate. None thought water skiing, recreational boating, or golf was needed, 95 percent said hunting, horseback riding, cabins, and vista points were "not needed." Given for each of the 19 lakes are: history of acquisition, financing, and development, location, size, attendance patterns, and average catch (in pounds) per lake surface acre. Management alternatives discussed. (Interview questionnaire and 10 references included.)

KEYWORDS: Fishing, Alabama, management, preferences.

548. Lovegrove, R. E., and D. D. Rohdy
1968. Estimated expenditures, by location, attributable to the 1967-68 special goose permit season in North Central Colorado. Colo. State Univ. Dep. Econ. NRE-2, 8 p.

A questionnaire was mailed to 10 percent, or 300, of the holders of special goose permits. Expenditure by the 168 respondents was about $145 each. Expenditures are broken into 17 categories. Forty-five percent of the hunters indicated willingness to pay $1 for a special goose permit.

The most common complaint was shortage of places to hunt. Over 26 percent of the sample failed to use their permits, which indicates that a nominal charge for the permit was justified. The economic contribution of the special goose season to local business in three Colorado counties is discussed.

KEYWORDS: Economics, Colorado, waterfowl, license fee.

549. Low, Jessop B.
1951. The role of checking stations in student training and wildlife research. 31st Conf. West. Assoc. State Game Fish Comm. 31: 142-144.

Students further their training at checking stations, and they help secure animal data. A brief history of Utah checking stations is given.

KEYWORDS: Utah, research methods, education.

550. Lucas, Robert C.
1965. The importance of fishing as an atrraction and activity in the Quetico-Superior area. USDA For. Serv. Res. Note LS-61, 3 p.

Motorized canoeists and boat campers, more than any other group, gave fishing as their reason for visiting the area. Complaints about fishing outnumbered disappointments over facilities, cleanliness, and crowding. Auto campers were the least approving of fish management programs. Compared with several other types of visitors, fewer resort guests chose the area because of fishing, but they fished more and were least satisfied.

KEYWORDS: Fishing, Minnesota, preferences, Great Lakes, Canada.

551. Lumsden, H. G.
1957. The problem of changing beliefs and attitudes. J. Wildl. Manage. 21(4): 463-465.

A group discussion is more effective in attitude change than written information campaigns, lectures, or individual instruction. Social support of progressive groups can be used to make converts.

KEYWORDS: Public relations, preferences.

552. Lundy, Herbert
1971. Can the sport of hunting be defended? Izaak Walton League Outdoor Am. 36(7): 5, illus.

Man is a hunter and he will always be a hunter. Hunting means the pursuit of game, the pitting of man's intellect and experience against the instincts of the quarry. It also means decent respect for the hunted. Hunters don't need any defense or apology for their sport. It is the total experience of hunting, not just pulling the trigger, that counts. Hunting is incompatible with mass recreation.

KEYWORDS: Antihunting, benefits.

M

553. McAllister, M. Hall
1930. The early history of duck clubs in California. Calif. Fish Game 16(4): 281-285, illus.

Organized duck clubs commenced when the Southern Pacific Railroad was built across the Suisun Marsh in 1878. This brought ducks and geese within a few hours of San Francisco and Oakland. Several early clubs, their organization, and sites are mentioned.

KEYWORDS: Historical value, waterfowl, clubs, California.

554. MacArthur, Arthur R.
1959. Wisconsin's licensed shooting preserves and fee-shooting game farms. Wis. Conserv. Bull. 24(8): 10-13, illus.

Given adequate incentive, landowners will provide hunting. Wisconsin's pioneer shooting preserve and game farm laws need revision.

KEYWORDS: Wisconsin, refuge, landowner-private, historical value, management.

555. McCabe, Robert A.
1954. Training for wildlife management. J. Wildl. Manage. 18(2): 145-149.

American wildlife management became a functioning entity after its metamorphosis from an art into a science. The three fundamental activities essential to training are: that man, animals, and plants have their roots in the soil; patterns in the ecosystem must be preserved; and conservation includes the wise use of our resources. Training for wildlife management is discussed at three academic levels: Bachelor, Master, and Ph.D. degrees.

KEYWORDS: Profession, education, management.

556. ________
1967. Contributions of laymen to North American wildlife research. 8th Congr. Int. Union Game Biol. Trans., Helsinki 8: 202-224, illus. (Reprinted from *Finnish Game Research* 30.)

Nonprofessionals often aid in the compilation of wildlife information. Professionals should seek such information through utilization of: historical reports, kill diary and kill reports, amateur bird banding information, Audubon bird counts, damage reports, interviews and questionnaires, crop reporting services, check stations, direct observation data, trophy specimen reports, animal accident reports, pesticide die-off reports, radar picture interpretation, rural mail-carrier tallies, information from prison labor, work camps, youth groups, and sportsmen's conferences. By utilizing data from nonprofessionals, the professional wildlife specialist can make his work less complicated. (References, 139.)

KEYWORDS: Profession, research methods.

557. McCartney, R. B.
1964. Field management of public dove hunting in the United States. 18th Conf. Southeast. Assoc. Game Fish Comm. Proc. 18: 185-187, illus.

Questionnaire was mailed to all States which had open season on mourning doves during 1963. The abundance of doves and the availability of hunting

areas varied widely throughout the United States. A table shows public dove hunting field management by State and land ownership classification. Techniques of dove field management vary and are still in the experimental stage. Dove hunting has steadily increased in popularity in States with an open season, which will result in more intensive management on both public and private lands. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Upland game birds, management, surveys.

558. McClelland, John
1957. How do we fit nonresidents into our fish and game harvest program. 37th Conf. West. Assoc. State Fish Game Comm. Proc. 37: 81-83.

Non-resident sportsmen are encouraged in Colorado (1) to assure adequate wildlife harvests and (2) because they greatly contribute to license revenues.

KEYWORDS: Economics, resident vs. nonresident, Colorado.

559. McCond, Ken
1967. Are hunting seasons getting safer? Mich. Conserv. 36(6): 19-21, illus.

Hunting accidents are discussed; examples are given. A table gives hunting deaths and injuries in Michigan from 1948 to 1966. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Safety, Michigan.

560. McConnell, Chester A.
1966. A survey of private commercial shooting preserves in Tennessee. 20th Conf. Southeast. Assoc. Game Fish Comm. Proc. 20: 161-180, illus.

Complete survey of Tennessee's shooting preserves includes a discussion of history, operational methods, upland game bird status, financial and management problems, big game preserves, and solutions to shooting preserve problems.

KEYWORDS: Tennessee, refuge, administration, economics, management.

561. McCormick, J. B.
1969. Trends in wildlife law enforcement: program management, a "systems" concept. 59th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 59: 77-81.

Program management is becoming evident as a management objective. Definite, detailed plans direct the organization's disciplines toward common objectives. Presented are the advantages of the "systems approach" of program management, the necessity of defining objectives of each function within the organization, and methods for evaluating the level of attainment reached at all levels of management. Particular emphasis is on problems associated with evaluation of law enforcement efforts.

KEYWORDS: Administration, enforcement.

562. McCracken, Harold

1924. The game situation in Alaska. Am. For. 30(366): 323-328, 362, illus.

Depletion of game by the Alaskan natives, market hunters, and workmen in canneries and construction camps illustrates the need for an Alaska Game Act to effectively regulate game conditions.

KEYWORDS: Alaska, legislation, historical value.

563. McCurdy, Dwight R., and Herbert Echelberger

1968. The hunting lease in Illinois. J. For. 66(2): 124-127, illus.

Three main factors affecting hunting leasing arrangements are: (1) activity for which the land is leased--for example, shooting preserves use more land than duck and goose hunting areas; (2) amount of investment in facilities--the more invested in the area, the longer and more complete the lease; and (3) whether or not the lease is a written agreement. This safeguards the hunter and landowner. Lease provisions are discussed.

KEYWORDS: Illinois, economics, lease.

564. _________ and Phillip K. Jenkins

1969. Duck hunters at the Oakwood Bottoms Greentree Reservoir, Shawnee National Forest, Illinois. South. Ill. Univ. Dep. For. Publ. No. 4, 20 p., illus.

Questionnaires were returned by 104 hunter-groups who hunted the seasonally flooded "green tree" reservoir. Duck hunters were generally young adults having less than 5 years of experience. They hunted in groups of two or three, traveled less than 25 miles from home, and stayed no more than 3 hours. Hunter opinion showed that the reservoir is a good-to-excellent place to hunt due to freedom of movement and little need for experience or equipment. "High shooting" was the main complaint. Hunters approved of shorter seasons and to a lesser extent a one-mallard limit as a means of adapting to lower duck populations. The Greentree reservoirs provide increased hunting particularly for novices. The distance hunters will travel to these reservoirs is short; 90 percent of the respondents lived within 50 miles.

KEYWORDS: Illinois, waterfowl, preferences, characteristics.

565. McDaniel, Jimmie

1965. Evaluation of utilization, harvest, and hunting pressure on privately owned hunting areas. 19th Conf. Southeast. Assoc. Game Fish Comm. Proc. 19: 60-68, illus.

Recommendations are given for economical operation, crop planting, blind construction, and area size for the management of private hunting areas.

KEYWORDS: Florida, economics, management, waterfowl, landowner-private, harvest statistics.

566. MacDonald, Duncan, and Everett G. Dillman

1968. Techniques for estimating non-statistical bias in big game harvest surveys. J. Wildl. Manage. 32(1): 119-129, illus.

Two sources of bias in mail questionnaire surveys are response bias and nonresponse bias. Response bias was tested in a 3-year survey of

deer hunters whose performance was known. Net error in estimating total deer harvest was 7.6 percent, with 9.1 percent of the unsuccessful hunters reporting a kill and 4.5 percent of the successful hunters reporting no kill. Followup mailings and personal contact tested nonresponse bias for 1 year, revealing a significant bias toward overestimation in the resident big game license category. Results suggest that the mail questionnaire method provides reasonable estimates of total harvest.

KEYWORDS: Harvest statistics, research methods, big game.

567. McDonald, John
1957. Part IV: The lady and the trout: Dame Juliana's legacy. Sports Illus. 6(22): 66-75, illus.

A survey of the vast field of angling literature since Dame Juliana Berners, which shows how her "Treatise" has influenced the sport of fishing for 500 years and left its imprint on everything that has been written by later authorities. (See also Duggan 1957a, 1957b, McDonald and Webster 1957.)

KEYWORDS: Fishing, literature, historical value, England.

568. _________ and Dwight A. Webster
1957. Part III: The lady and the trout: the tying of the flies. Sports Illus. 6(21): 52-58, 63-68, illus.

An analysis of the first set of artificial trout flies bequeathed to history by Dame Juliana Berners, a 15th century nun. Indicates how they were tied and shows some in full color illustrations. (Also see Duggan 1957a, 1957b, McDonald 1957.)

KEYWORDS: Fishing, historical value, England, literature.

569. Mac Duffie, Joyce S.
1963. Hunter safety with a new look. 43d Conf. West. Assoc. State Game Fish Comm. Proc. 43: 317-322.

Paper describes Montana's success story with hunting safety classes, including methods which attracted all firearms users, regardless of age or sex.

KEYWORDS: Safety, Montana, education, communications.

570. McDuffie, Ronald C.
1943. Attitude of Palouse farmers towards farm game. J. Wildl. Manage. 7(3): 343.

Visits to 138 landowners and tenants in 1940 on southeastern Washington wheat farms yielded only three farmers interested in feeding game birds on their land. Most farmers were unconcerned about game unless it interfered with farm operations.

KEYWORDS: Landowner-private, preferences, Washington.

571. McFadden, James T.
1969. Trends in freshwater sport fisheries of North America. Am. Fish. Soc. Trans. 98(1): 136-150, illus.

Increasing population will place increasing demands on freshwater fisheries. It is useful to consider sport fishing value as a function of

fishing effort rather than exploitation rate. In addition, purely esthetic considerations are important and this value is roughly parabolic relative to fishing effort. This theoretical paper considers fishing yield, value, and cost in a model. At any level of fishing effort, the value accruing from the catch is added to the esthetic value of the fishing experience. Sport fishery management lacks a defined objective, but two extremes are considered. Under a very businesslike view, with society considered a monopolistic power of sport fishing, the number of fishermen would have to be limited in order to maximize value. In contrast, participation would be restricted so fishing effort could continue to increase as population grows provided that value, sufficient to cover costs, can be extracted from the fishing experience. Maximization of profit is an inappropriate objective because too low a level of participation is entailed. At the level of maximum participation too small an aggregate value is realized from the resource. Because the value of any particular fishery varies greatly with individuals, socially successful management will consist of reducing the variance about the value curve by providing a wide variety of recreational fisheries, each managed for a narrow range of values.

KEYWORDS: Fishing, resource use, economics, benefits, crowding.

572. Machan, Wayne J., and Robert D. Feldt
1972. Hunting results on cropland adjustment land in northwestern Indiana. J. Wildl. Program Manage. 36(1): 192-195.

Hunting success on five areas under the Cropland Adjustment Program (CAP) was compared with the success of three nonparticipating areas. Data show a 25-percent lower kill per hunter on CAP land but four times greater game kill. The variation is explained by heavy hunting pressure as a result of increased public access. Agency cost per hunter effort tended to decrease over successive years.

KEYWORDS: Upland game birds, Indiana, access, legislation, crowding.

573. McHugh, John E., Jr.
1956. The construction and validation of a written knowledge test for students of a basic rifle marksmanship and hunting course. M.S. thesis, Pa. State Univ. 231 p.

The construction and validation of the test for nomenclature, safety, sighting, aiming, and firing positions was carried out on Pennsylvania State University freshmen and sophomores who registered for a course in marksmanship and hunting safety. An initial test of 113 multiple choice, situation, identification, and matching questions were administered to 176 students who had had no formal instruction in subject being tested. Five judges or experts in marksmanship and hunting safety analyzed test results using item selection analysis, index of discrimination, and difficulty rating. Of the 113 original questions, 96 were judged acceptable, and a second test containing these questions was given to 180 different students who *had* completed the knowledge phase of the course. Item analysis and difficulty ratings of this second test eliminated another 28 questions. Author concludes that the 68 items "seemed to be a valid and reliable measure" of basic marksmanship and hunting safety for the college level course. (Presented are materials for an instructor such as a statement of course objectives, a detailed course outline consisting of 24 lessons 50 minutes long, basic knowledge test, bibliography of source material, and the hunter safety test along with sample answer sheets. Treatment of marksmanship and safety testing is comprehensive. References, 18.)

KEYWORDS: Safety, education.

574. McIlroy, Carl W.
1972. Effects of hunting on black bears in Prince William Sound. J. Wildl. Manage. 36(3): 828-837, illus.

Recently, hunting of black bears has extended from Valdez, Alaska, into previously unhunted regions in Prince William Sound. The success of hunters without guides has declined markedly since 1966, with greater numbers of hunters going on guided hunts and relatively more bears being killed at greater distances from Valdez. The sample of bears was biased towards older male bears. There appears to be a density level of black bears below which further hunting with the techniques employed is unproductive.

KEYWORDS: Big game, harvest statistics, Alaska.

575. McIntosh, Kenneth Dale
1966. Privately-owned hunting lands in West Virginia: supply, quality and access arrangements. Ph.D. diss., Univ. Wis., 324 p.

Three important supply factors which affect the marketing of hunting rights in West Virginia are poor habitat lands, large areas of open, free hunting, and the fact that landowners (70 percent of those interviewed) oppose hunting fees. A landowner questionnaire survey also indicated that 94 percent of those interviewed allowed free hunting with permission. Because abandonment of farmlands and habitat loss continues, because the acreage of State-owned or -leased hunting lands is also increasing, and because landowners value open and free hunting, there does not appear to be much opportunity in the near future for increased income to private landowners from the marketing of hunting rights. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Landowner-private, user fee, West Virginia, access.

576. McKean, John W.
1967. Deer hunter preferences. 47th Conf. West. Assoc. State Game Fish Comm. Proc. 47: 221-227.

A single questionnaire mailed to 4,066 Oregon deer hunters yielded a 66-percent return. There was an 18-percent turnover or recruitment of hunters in 1966. Although deer hunting was allowed from September 10 through December, 89.5 percent of the deer hunting occurred between the 1st and 13th of October. Seventy-three percent were weekend hunters. Those using vacation time for hunting averaged 7.5 days and 68-percent success. The average for all hunters was 5.6 days of hunting and 55-percent success. Approximately 50 percent of the deer hunting was in 1-day trips. Of those greater than 1 day, 22 percent stayed in trailers or campers, 17 percent in tents, 7 percent in motels, and 4 percent camped without shelter. Only 13 percent used developed campgrounds and only 1.2 percent paid a hunting access fee. Application of these data to management is made.

KEYWORDS: Management, Oregon, big game, preferences.

577. McKee, Brumell
1967. The violator. Mich. Conserv. 36(2): 2-6, illus.

Michigan sets the yearly illegal deer kill at 50,000, or about half of what is killed legally. Increasing public concern and more stringent sentences for violators are cited.

KEYWORDS: Enforcement, law violation, Michigan.

578. McKeon, Warren H., William F. Hollister, and Michael Rodak
1966. Public hunting as a game management tool in southeastern New York. 31st Conf. North Am. Wildl. Trans. 31: 307-323, illus.

This is a brief history of controlled public hunting in Putnam County since 1939, with particular emphasis on the first controlled hunting area established in 1959. Discussion of organization and hunt procedure includes a "cooperative agreement" for landowners and a list of permittee regulations. The high records of hunter success and hunter information continue to be reliable. The area provides hunting without obligation other than law-abiding and courteous behavior. Game take is secondary to hunting opportunity; and although hunters take only one piece of game per 4.3 hunters, their satisfaction indicates the important recreational value of the area.

KEYWORDS: Management, historical value, New York.

579. McLaurin, Edmund
1951. Boys...gals...and guns. Fla. Wildl. 5(5): 4-5, 26-29, 32, illus.

Article describes Florida's gun safety education program.

KEYWORDS: Safety, New York, Florida, education.

580. _________
1959. Safe--or sorry? Fla. Wildl. 13(4): 24-27, 41, illus.

Article discusses hunting accidents and promotes hunter safety education.

KEYWORDS: Accident, safety, Florida, education.

581. _________
1964. Shooting preserves. Fla. Wildl. 17(9): 12-15, 28, illus.

This is a popular article telling about private shooting preserves in Florida. Discussed are preserve characteristics, objections to planted birds, and special programs to attract hunters. Hunting birds with bow and arrow is an example of a special program. Fifteen preserves are listed by name and address.

KEYWORDS: Florida, plant and shoot, archery.

582. McLean, J. H.
1954. Welcome mat for sportsmen. Wis. Conserv. Bull. 19(7): 30-31, illus.

No fees are required to fish on 15,000 acres in 11 lakes created by river developments of the Wisconsin-Michigan Power Company.

KEYWORDS: Wisconsin, Michigan, fishing, resource use, user fee.

583. McLean, Jay
1958. School for sportsmen. Field Stream 63(3): 60-62, 114, illus.

Forest Lake School, a 2,000-acre preserve 4 hours drive from New York, provides training in bow hunting, bird shooting, fishing, fly tying, camping, cooking, canoeing, photography, snowshoeing, tracking, and outdoorsmanship.

KEYWORDS: Fishing, education, New York.

584. McLeod, Kenneth, Jr.
1926. Deer in their relation to man and forest. M.S. thesis, Univ. Calif., 87 p.

To identify policies and economic principles applicable to deer management, the author recorded personal observations while traveling several thousand miles from southern California to British Columbia. Economic values of deer include use as domestic food supply, esthetics, and hunting recreation. "Mental stimulation" (movies, magazine reading) is equated to stimulation gained from wildlife as esthetics. Accordingly, deer are worth about $15.95 per head as "creators of aesthetic values" based upon cost of similar stimulation such as movies and magazines. Similarly, hunting values are compared to commercial recreation offering physical stimulation. The hunting value is slightly in excess of esthetic value. Deer management problems are discussed for Federal, State, community, and private ownerships. The analysis is based upon many unfounded assumptions and opinions. Method of placing dollar value on esthetic wildlife recreation opportunities has merit.

KEYWORDS: Economics, management, big game, benefits.

585. McMillan, Covington
1936. The history of angling and the technique of casting. M.A. thesis, George Peabody Coll. Teach., 205 p., illus.

Angling, highly developed during prehistoric times, was a popular sport among the nobles of ancient times and was recommended to the clergy during the Middle Ages. Angling techniques and fishing equipment of the Middle Ages were same as those of ancient times. Modern angling is characterized by large numbers of anglers, technical and scientific nature of literature, fish preservation laws, fish management, the rise of fishing clubs, and the use of the reel. Modern fly and bait casting techniques, equipment, and tournaments are discussed. Casting, requiring skills similar to angling, is less expensive. (Rich in historical perspective; includes detailed diagrams of casting techniques. References cited, 52.)

KEYWORDS: Fishing, historical value.

586. MacNamara, L. G.
1961. Shooting preserves in New Jersey. North Am. Game Breeders Assoc. Conv., 1961, 8 p., illus.

New Jersey started its commercial shooting in the 1930's under the semiwild shooting preserve law. In 1948, 68 preserves were operating and, by 1960, 143 preserves controlled 30,423 acres of land. Most were operated by sportsmen's clubs. The semiwild shooting preserves have progressed substantially because most are not operated for a profit. Preserves face the same problems as agricultural businesses.

KEYWORDS: Clubs, economics, New Jersey, upland game birds.

587. ________ Aldo Leopold, Frank B. O'Connell, John D. Chalk, and Logan J. Bennett
1936. Farmer-sportsman cooperatives. 1st Conf. North Am. Wildl. Trans. 1: 275-296, illus.

Paper gives series of speeches concerning problems of hunting on private land. In New Jersey the sources of hunting land accessible to the licensed hunter are farmer-sportsman cooperatives, sportsman club lands, public shooting grounds, and general open lands. For the North Central region, 18 types of farmer-sportsman areas which have been tried are summarized, and the change in objectives from 1931 to 1936 is examined.

Nebraska stresses the farmer's role in raising game for cooperatives. North Carolina's program centers on education, and Iowa, a State that finds 95 percent of its land devoted to agriculture, criticizes its farmer-sportsman plan and discusses revisions.

KEYWORDS: Farmer-sportsman relations, management, New Jersey, Nebraska, North Carolina, Iowa, historical value.

588. McNeil, Richard Jerome
1963. Population dynamics and economic impact of deer in southern Michigan. Ph.D. diss., Univ. Mich., 191 p.

Deer in Michigan's 34 southern counties disappeared in the 1800's and reestablished themselves in the 1920's. They cause automobile accidents and considerable farm damage. Value of damage includes \$340,000 to crops, \$300,000 to vehicles, and \$70,000 hunter-caused damage. However, total benefits exceed total costs. Regulation of deer numbers will ultimately depend upon net benefits to society rather than food or similar environmental factors. Ideally, costs should not be incurred by those individuals who do not receive benefits. (Condensed from *Dissertation Abstracts.)*

KEYWORDS: Big game, Michigan, economics.

589. Maddock, Stephen J., George A. Gehrken, and W. Alan Guthrie
1965. Rural male residents' participation in outdoor recreation. USDA For. Serv. Res. Note SE-49, 2 p., Southeast. For. Exp. Stn., Asheville, N.C.

In a study of 200 Brunswick County, Virginia, residents, 88 percent were male. Eight activities--picnicking, hunting, fishing, hiking, swimming, boating and canoeing, camping, and nature or bird walks--are summarized as to days of activity per male participant. Hunting and fishing accounted for 78 percent of the total outdoor recreation activity. Over a year's period, 76 percent of the male residents engaged in some form of outdoor recreation for 10 or more days.

KEYWORDS: Virginia, preferences, non-consumptive use, resource use.

590. Madson, John and Ed Kozicky
1964. The hunting ethic. Rod Gun. 66(3): 12, 24.

The hunting ethic is a mature, thought-out approach to the instincts, emotions, and backgrounds that make a man want to hunt. Hunting is a love for nature resulting from the peace; it is a deep and mystic respect for animals. As a person's regard for wildlife grows, it becomes a sportsmanship fed by experiences, sympathy for wildlife, game laws, and the sportsman code under which game is hunted. Some hunters never learn, and they become game hogs. However, the real hunter's personal ethic constrains him to kill mercifully and only when it won't endanger the game supply. The one word that sums up the hunting ethic is respect--respect for your hunting companions, for land, for wildlife, and for yourself.

KEYWORDS: Esthetics, philosophy.

591. Madson, John
1953. That old black magic of hunting. Tex. Game Fish 11(9): 16-17, 28, illus.

Hunting superstitions are collected from Ireland, England, Germany, Persia, Belgium, and the United States. Examples are: Shooting performance

improves if you rub the gun stock on your left leg three times. If you are after 'possum, don't leave home until you have greased your dog's left front foot with bacon fat.

KEYWORDS: Folklore, historical value, foreign country-general.

592. _________
1967. The hunters. Nev. Outdoors Wildl. Rev. 1(4): 13-15, 22, 24, 26, illus.

A wave of antihunting sentiment is building behind the antigun legislation. Few nonhunters realize the need hunters have for elemental competition and the ancient, basic test of manhood which the sport provides. The hunter doesn't feel tenderness and love for animals but respect and pride. He kills them within a rigid ethical framework, out of a basic need to participate in wilderness in a traditional role. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three by Bureau of Outdoor Recreation.)

KEYWORDS: Legislation, tradition, antihunting, benefits.

593. _________
1970. British look at U.S. hunting. Izaak Walton Mag., Mar., p. 11.

A britisher observes that the American "free hunting" ideal is becoming unworkable in the 20th century.

KEYWORDS: England, administration, license fee.

594. _________ and Ed Kozicky
1971. Game, gunners and biology--the scientific approach to wildlife management. 48 p., illus. East Alton, Ill.: Conserv. Dep., Winchester West. Div., Olin. Corp.

Article gives an excellent history of wildlife management in the United States covering wildlife depletion, legislation, protection, conservation, education, research, financing, and benefits. A major point is that wildlife biology research and education has accounted for progress in the field to date.

KEYWORDS: Historical value, conservation, legislation, management, farmer-sportsman relations, economics.

595. _________ Ed Kozicky, and Ozz Warbach
1972. A law for wildlife, model legislation for State nongame wildlife conservation program. 20 p., illus. East Alton, Ill.: Conserv. Dep., Winchester West. Div., Olin Corp.

Because non-game species are not hunted they are left out of hunter-sponsored conservation programs of positive management. While many species are totally protected from shooting they are not protected from technology of intensive farming, bulldozers, or draglines. Although most Americans will never hunt, the chance to enjoy wildlife is a birthright and valuable because wildlife is an indicator of environmental conditions in general. Over half the publication is a model law for States to follow in developing non-game species programs. This was originally developed by the International Association of Game, Fish, and Conservation Commissioners and the Wildlife Society. Four approaches to founding the management of non-game and endangered species are given.

KEYWORDS: Non-consumptive use, legislation.

596. Maghakian, John
1969. Ocean fishing for Los Angeles youth. Parks Rec. 4(7): 32, illus.

Disadvantaged youngsters in Los Angeles participated in a summer fishing program at a cost to the city of $19,000 in 1968.

KEYWORDS: Fishing, non-consumptive use, California, urban wildlife.

597. Mahoney, John
1960. An economic evaluation of California's sport fisheries. Calif. Fish Game 46(2): 199-209.

A statewide economic evaluation of sport fishing in California was made in 1956 by means of a questionnaire mailed to license buyers. In 1955 each salt-water angler spent an average of $141.54 and $12.51 daily. This amounts to $92,200,000 for the economy. The total includes $1,500,000 expended by purchasers of 3-day special licenses, who spend an average of $36.15 for their 3 days of angling. Fresh-water anglers spent an average of $217.89 annually and $14.27 daily, with an estimated total of $226,884,935 for the year.

KEYWORDS: Fishing, economics, California.

598. Mahoney, Justin T.
1952. The posting law. N.Y. State Conserv. 7(1): 22-23.

Article has question-answer discussion on aspects of the posting law: how to post, the effect of posting, fines for violation, and legal aspects.

KEYWORDS: New York, legislation, access.

599. Malaher, G. W.
1967. Improper use of snow vehicles for hunting. 32d Conf. North Am. Wildl. Trans. 32: 429-433.

Snow vehicles can legitimately be used for transportation to a hunting area and for retrieving big game. Hunters, however, do not restrict themselves to these uses, and abuses such as combined machine hunting, often in conjunction with aircraft, have resulted in harassment of big game and complaints from hunters on foot. Various restrictions, licenses, and educational measures are suggested.

KEYWORDS: Management, law violation, equipment.

600. Maliepaard, Hugo S.
1962. Development of a moose harvest plan for the commercial forest zone, Saskatchewan. M.S. thesis, Mont. State Univ., 130 p.

Mail questionnaire sample of 1,250 Saskatchewan moose hunters yielded 61.7-percent return. Moose hunting by boat was less time consuming and yielded greater success than hunting on foot or by car. The use of a guide increased the probability of success. American hunters were more successful than Saskatchewan hunters due to greater use of boats and guides. Moose were most often killed during 8-10 a.m. and 4-7 p.m. for the 1959-61 hunting seasons. Kill decreased as season advanced, but the percent success increased. Gun calibre had little or no influence on success of failure of moose hunting. Management implications are discussed and suggestions given.

KEYWORDS: Big game, harvest statistics, Canada, management, guide.

601. Mann, Roberts
1954. Aldo Leopold priest and prophet. Am. For. 60(8): 23, 42-43.

The essay appraises the life and land ethic of Aldo Leopold.

KEYWORDS: Conservation, historical value, biography, philosophy.

602. Manning, Glenn Herbert
1968. Demand relationships for outdoor recreation in Iowa. Ph.D. diss., Iowa State Univ., 136 p.

Data from a 1966 statewide recreation survey for Iowa were used to develop a reliable method for estimating future consumption of outdoor recreation. Results show a sharp increase in the following activities by 1980: golf, bird watching, and attending outdoor concerts or plays. Decreases are predicted for bicycling, horseback riding, baseball, hunting, and fishing. Sharpest increase in need will occur in activity-oriented areas, followed by intermediate and resource-based areas. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Iowa, preferences, non-consumptive use, fishing.

603. Mantle, C. J.
1955. A commissioner's viewpoint of research in establishing annual hunting and fishing regulations. 45th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 45: 72-77.

Author suggests that research is valuable but commissioners should be aware of objectionable as well as the favorable aspects of a study. Dangers can result if technical reports are not reviewed before presentation to the public. Advice and examples are given for those responsible for implementing research findings.

KEYWORDS: Arizona, research needs, management.

604. March, James R., and Richard A. Hunt
1968. A survey of open waterfowl hunting in Wisconsin in 1967. Bur. Res. State Wis. Dep. Nat. Resour. Rep. No. 35, 12 p., illus.

Of 3,117 hunting permits issued during an experimental waterfowl season, 502 were issued with a diary or report card. After a followup letter, 218 diaries (43 percent) were returned. Hunter participation was lower than anticipated; only 13 percent of the respondents reported one or more open water hunting trips. Hunter party size was 2.4 persons on the Mississippi area but only 1.8 on the Lake Winnebago area. Hunters who used more than two decoys had better success (2.3 ducks per trip) than hunters with two or less decoys (0.6 duck per trip). Results indicate that open water shooting is a specialized sport that attracts highly equipped hunters.

KEYWORDS: Waterfowl, Wisconsin, harvest statistics.

605. Marks, Stuart Alexander
1968. The role of classification and belief in Bisa use of mammalian resources. Ph.D. diss., Mich. State Univ., 166 p.

Study attempts to delineate and define a Central African Society's perception of wild mammals and to show how social and belief systems operate to influence the selection and utilization of resources. Data

were gathered in 14 months of field work among the valley Bisa of Zambia. Wild game is the predominant source of meat for the Bisa. They classify mammals and birds by size, sex, color, dangerous mammals, and those formerly used as tribute to chiefs. The distribution of and prohibitions on the consumption of certain meats are discussed. The sightings of certain mammals and birds are considered omens; and in the past, male or female animals were used for divinatory purposes. Status and role of hunters was determined through their knowledge of medicines commensurate with proven skills and killing of important mammals. A hunter's ritual entry into manhood is described and its symbols interpreted, along with his accompanying duties, privileges, knowledge of tradition, and responsibilities to his kin. The use of symbols portrays a segment of Bisa beliefs and values which channel the society's perception and use of its environmental products. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Zambia, resource use, tradition.

606. Marsh, John
1970. Bears and the public in our National Parks. Can. Audubon 32(2): 43-45, illus.

Interviews with 100 people were made in Banff and Glacier National Parks in Canada. Only 50 percent were Canadian residents; 84 percent had seen bears in the wild; 20 percent said bears discouraged them from hiking; only 10 percent were discouraged from camping; 2 percent wanted all bears eliminated from the parks; 19 percent thought grizzlies should be eradicated; 1 percent were uncertain about removal of all bears; 17 percent were uncertain about removal of grizzlies; and 10 percent believed bears should always be left alone regardless of their actions. Some people suggested allowing park visitors to carry firearms, but 80 percent of those interviewed objected to this. Further understanding of bear behavior is necessary to avoid further human injury and ultimate elimination of bears.

KEYWORDS: Canada, big game, safety, preferences.

607. Marsh, John S.
1972. Bears and man in Glacier National Park, British Columbia, 1880-1980. 2d Conf. Int. Union Conserv. Nature Nat. Resour. Morges, Switzerland, 23: 289-296.

The chronology of bear-man relationships started from construction of the Canadian Pacific Railway. Bears were regarded with a mixture of fear and sportsmanship during the first 30 years of tourism. Railroad interests promoted hunting until 1904; however, not until 1919 did the Federal Government gain control of wildlife in the parks. Hunting and poaching continued until 1930. During the 1920's residents complained about bears, and bear-man interactions increased due to artificial feeding (garbage) of bears. Current visitor attitudes were obtained from an interview of 114 park visitors. Results indicated that the fear and ignorance expressed by park visitors and residents at the turn of the century have declined; the aggressive sporting interest in bears has given way to a more passive, observational, and photographic enthusiasm. Recommendations for future survival of the bears include: further research, improved garbage disposal, improved design of facilities, creation of a bear refuge area, improved management techniques, education, and enforcement of laws.

KEYWORDS: Big game, historical value, Canada, non-consumptive use, safety, preferences.

608. Martin, Elwood M.
1966. Characteristics of waterfowl hunters; a study of activity categories. USDI Bur. Sport Fish. Wildl. Serv. Admin. Rep. No. 100, 12 p., illus.

Hunting activities of duck stamp buyers were examined for a 2-year period. Results indicate that 60 percent of those who purchased a duck stamp bagged at least one duck, 5 percent shot only waterfowl other than ducks, 15 percent hunted unsuccessfully, 20 percent did not hunt, and 37 percent of the successful duck hunters bagged 75 percent of the ducks taken each season.

KEYWORDS: Waterfowl, characteristics, surveys.

609. Martin, Lewis E.
1958. Shooting preserves and their place in wildlife management. 48th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 48: 88-92.

The development of an expanded shooting preserve program will not compete with public hunting, but it will fill the vacuum created by diminishing public hunting opportunities. Included are laws suitable for managing a preserve.

KEYWORDS: Management, refuge.

610. Martin, William E.
1963. Factors related to big game hunting accidents in Colorado. M.S. thesis, Colo. State Univ., 94 p., illus.

Mailed questionnaires, to 950 randomly chosen big game hunters from 1958 to 1961 seasons to determine conditions during unintentional and intentional firearm discharge, yielded 56-percent return. Hunters (155) experiencing potential accidents were sent a second questionnaire for more detail, and 78 hunters (6.6 percent of the original sample) returned the questionnaire. Results indicated over half the accidents were unintentional and self-inflicted, and 40 percent occurred when victim was not hunting. Of the intentional firearm discharges, 62 percent of the victims were mistaken for game. Students and semiskilled laborers were over-represented in accidents, and number of years a person has hunted was not a clear index of hunting safety. (Good literature review. A possible compounded non-response bias may exist in data.)

KEYWORDS: Accident, Colorado.

611. Martinson, R. K., and D. E. Whitsell
1964. Biases in a mail questionnaire survey of upland game hunters. 29th Conf. North Am. Wildl. Trans. 29: 287-294.

Field records were kept for Spring Valley Wildlife Area (Ohio) hunters during the 1961 and 1962 seasons. The same hunters later received questionnaires. Hunting trip and game kill estimates derived from the questionnaire data were higher than the known totals for those items. Errors are attributed to response and non-response bias. Hunters reported killing more game and making more hunting trips than they actually did. Nonrespondents were less persistent in their hunting effort and killed less game than they reported in the questionnaire.

KEYWORDS: Research methods, upland game birds, harvest statistics, Ohio, small game.

612. Martz, Gerald F.

1966. To shoot or not to shoot? Wis. Conserv. Bull. 31(5): 16-17, illus.

"Species management" through regulations requiring hunters to identify waterfowl species before shooting is proving successful for wood ducks in Wisconsin. Such regulations may lead to increased illegal kill. One illegal duck kill per 13 legal kills was observed, and other studies show a 16-percent illegal hen pheasant kill each year. Hunters have advocated closed seasons on birds in short supply, but officials believe this to be unrealistic due to reductions in license fee revenues.

KEYWORDS: Preferences, harvest statistics, management.

613. Mathews, Stephen B., and Gardner S. Brown

1970. Economic evaluation of the 1967 sport salmon fisheries of Washington. Wash. Dep. Fish. Tech. Rep. No. 2, 19 p., illus.

An economic evaluation was obtained by mail questionnaires to 5,000 randomly chosen 1967 salmon license holders. Responses from 2,146 who actually fished showed an estimated gross annual fishing expenditure by all anglers of $20 million. Non-resident salmon anglers accounted for $4.5 million, and the amount anglers would be willing to pay in order to continue fishing was $65 million. Net values per fishing trip and catch per trip were also obtained. A figure of $28 per fishing day is recommended as an absolute minimum for evaluating salmon fisheries threatened by water-based industries. Federal agencies commonly place the value at only $6 per day, although the direct cost of catching a salmon is about $20.

KEYWORDS: Fishing, economics, Washington, benefits.

614. Matson, Arthur James

1964. Improving productivity of South Dakota land resources for upland game birds and waterfowl through adjustments in institutions. Ph.D. diss., Iowa State Univ., 350 p.

Study considers the allocation of recreational resources for the purpose of State economic development. Analysis is made of demand and supply which influence investments in game birds. Special attention is accorded the institutions affecting the production and hunting of upland game birds and waterfowl. Findings demonstrate an imbalance in investment between classes of game birds. Multiple regression analysis suggests that development of the State's pheasant resource can result in increased incomes to the people of the State. Higher incomes to the State from improved productivity of resources for upland game birds may serve to reduce competition for participation in hunting between residents and nonresidents. Management of a resource base for migratory waterfowl is reviewed by examination of State prerogatives to remove uncertainties in jurisdiction over lakes. The allocation of resources to give maximum economic returns is held to be consistent with the value typically associated with outdoor recreation, given flexibility in institutions. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Waterfowl, economics, South Dakota, upland game birds, management.

615. Mattfeld, George Francis

1964. Kinds of land used by deer hunters in Michigan with methodology and analysis of data collection. M.S. thesis, Univ. Mich.

Restricted to University of Michigan campus use.

KEYWORDS: Preferences, resource use, research methods, Michigan, big game.

616. Merwin, Jack

1972. They're stealing your game. Outdoor Life 150(4): 79-81, 142, 146, illus.

The illegal killing of wild game is a growing threat. Violators fall into these four categories: the professional who sells meat, the vandal poacher who shoots and leaves a deer, the man who harvests meat for his own year-round use, and the hunter-poacher who deliberately shoots an illegal animal during legal hunting seasons. Professional poachers account for less animal destruction than do vandal-poachers or illegal meat hunters. Research in Idaho and Maine indicates that only about 1 percent of the total violations that occur are detected in the field. Several States estimate losing half as many big game animals to poachers as to legal hunters. Most conservation officers feel harsher penalties should be imposed. South Dakota has passed two such laws, one authorizing the game department to sue convicted violators to recover damages and one which requires judges to revoke the convicted violator's license for a year. Little poaching is done for needed food.

KEYWORDS: Enforcement, law violation, big game.

617. Metcalf, George, and Harold Harper

1950. Cooperative hunting areas in California. 30th Conf. West. Assoc. State Game Fish Comm. Proc. 30: 95-96.

Data from a 1949 study of six regulated hunting areas in California include the following: a total of 41,166 hunter days were spent and 13,452 cock pheasants were bagged (70 percent of these cocks were wild). Hunters took 47 percent of the liberated game farm pheasants. Controlled hunting was favored by 95 percent of the hunters.

KEYWORDS: Harvest statistics, California, upland game birds, preferences, management, plant and shoot.

618. Meyersohn, Rolf

1969. The sociology of leisure in the United States: introduction and bibliography, 1945-1965. J. Leisure Res. 1(1): 53-68.

Part I reviews various kinds of research on American use of leisure time with an evaluation of the strengths and weaknesses of each. Many research efforts have examined only the surface manifestations of leisure and have failed to delve into fundamental questions. Part II is a bibliography including titles under bibliographies on leisure, general works, theoretical discussions, economic studies, socioprofessional status, working class, children, adults, family, the aged, urban and suburban leisure, voluntary organizations, mass entertainment, and outdoor recreation including travel.

KEYWORDS: Non-consumptive use, research methods, surveys, bibliography.

619. Michael, Haskell T.

1958. Extra profits from wildlife. Soil Conserv. 23(9): 190-192, illus.

Farmers and ranchers on the Texas Gulf Coast obtain a substantial income from hunting and fishing rights on their ricefields and ranges. Some farmers reported as high as $25 per acre income. One 16,693-acre ranch experienced 5,000 hunters in 1 year at an admission fee of $5 per day for duck and goose hunting privileges.

KEYWORDS: Texas, farmer-sportsman relations, economics, waterfowl, benefits.

620. Mikula, Edward J., Gerald F. Martz, and Carl L. Bennett, Jr.
1972. Field evaluation of three types of waterfowl hunting regulations. J. Wildl. Manage. 36(2): 441-459.

A Michigan experiment compared the merits of three duck hunting regulations: a point system, a simple two-bird limit, and a species-oriented regulation. Bag checks and observations of hunters were used to evaluate the systems. Results indicate 33 percent of the hunter parties violated the species-oriented regulations, 16 percent violated the point system, and 18 percent violated the two-bird limit. Overshooting the legal limit was the predominant violation in all systems. Opinions of 2,727 hunters indicated that 69 percent preferred the point system, 20 percent the species-oriented regulations, and 11 percent the two-bird limit. The point system came closest to achieving a desirable end because it provided hunting opportunity, maximum hunter satisfaction, and acceptable hunter behavior.

KEYWORDS: Management, waterfowl, legislation, preferences, Michigan.

621. Miles, Lee
1930. The need of a Federal shooting license for migratory birds. 22d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 22: 106-109.

A Federal shooting license would equalize the rights of Canadian and American citizens and provide funds for the Bureau of Biological Survey.

KEYWORDS: Waterfowl, legislation, Canada, license fee.

622. Miller, Beverly Gene
1967. User opinions of the land and water conservation entrance fees at Crab Orchard National Wildlife Refuge. M.S. thesis, South. Ill. Univ., 62 p.

A sample totaling 841 users was interviewed at recreation areas within the Crab Orchard Refuge between May and September 1966 to determine opinions and knowledge regarding the Land and Water Conservation Entrance Fees and to determine if they were related to user characteristics. Users were generally middle-aged professional people from urban communities. They participated as a family and stayed no more than 6 hours. Primary activities were swimming and picnicking, and speedboating and water skiing were secondary. Nearly all were local residents who had visited the area previously and were dissatisfied with bathhouse and restroom facilities. Most visitors were in favor of an entrance fee. No consideration was given to opinions of recreationists attracted by wildlife, especially hunting.

KEYWORDS: User fee, refuge, lesiglation, preferences.

623. Miller, Herbert J.
1950. Managed hunting on a public marsh. 15th Conf. North Am. Wildl. Trans. 15: 505-511.

The Pte. Mouillee plan is an efficient and workable procedure for managing a heavily hunted public marsh. For five seasons annual average hunting pressure was 3.1 hunts per acre on the controlled hunting unit where maximum pressure permitted was 300 hunters on 1,700 acres. Estimated total public use of the entire area, hunting plus other recreations, averaged 20,000 man-days annually. The average annual harvest of the controlled unit was 15.7 units of game per 100 gun-hours. Gun accidents were at a minimum and reasonable hunting opportunities were provided for a large number of wildfowlers. The purchase of high value marsh property seems justified if carefully managed.

KEYWORDS: Management, waterfowl, harvest statistics, Michigan.

624. Miller, Townsend
1957. The impact of hunting and fishing in Texas. Tex. Game Fish 15(1): 10-11, illus.

Highlights are given of a 1955 U.S. Fish and Wildlife Service fish and game survey in Texas. Compares Texas hunting and fishing with the national average.

KEYWORDS: Economics, Texas, characteristics.

625. Mississippi Flyway Council
1962. Quest for quality. Wis. Conserv. Bull. 27(5): 12-13, illus.

The Mississippi Flyway Council defines quality waterfowling. The council maintains that small bags of game taken under sporting conditions provide more enjoyment to the sportsman than full bag limits taken under unsporting conditions, and that limiting gun pressure is the best way to perpetuate hunting quality. American waterfowl hunting tradition rests on the idea of a contest between a wary bird and a skillful hunter in an appropriate setting, that the sportsman exhibit his skill in various ways, that an elemental marshland be undefiled by unnatural objects, and that sky-busting and symptoms of poor sportsmanship be discouraged. The council recommended that public duck blinds be spaced at a minimum of 200 yards apart and that boats be closely regulated. Rather than "more birds per hunter," the slogan for the future should be "more pleasure per bird."

KEYWORDS: Esthetics, waterfowl, management.

626. Moe, Homer E., and Kenneth L. Corbett
1965. I don't want to get involved. Wis. Conserv. Bull. 30(5): 20-21, illus.

The public need not fear "involvement" in court and can help convict game law violators simply by providing the warden with facts.

KEYWORDS: Enforcement, law violation.

627. Mohler, Levi L., Paul D. Dalke, and Wesley M. Shaw
1958. Elk and elk hunting in Idaho. 23d Conf. North Am. Wildl. Trans. 23: 491-501.

Records from 64,724 bagged elk show that females made up 50 percent of the kill in either-sex hunts. Hunter success averaged nearly 30 percent but exceeded 50 percent in a few areas. During each of the last 3 years, elk tag sales have exceeded 50,000 and kill has been in excess of 12,000. Adequate harvesting in remote areas is facilitated by general hunts to encourage hunter participation.

KEYWORDS: Idaho, either-sex hunt, harvest statistics, big game.

628. Moncrief, Lewis Whitfield
1970a. An analysis of hunter attitudes toward the State of Michigan's antlerless deer hunting policy. Ph.D. diss., Mich. State Univ. 258 p.

Results from 398 randomly selected hunters from three regions of Michigan indicate differences in attitude toward policy. The highest socio-economic status group is the most supportive, while the lowest socioeconomic status group was least supportive. Individual attitudes were definitely linked to attitudes of relatives and hunting companions; neighbors,

fellow-workers, and social acquaintances were not very influential in attitude formation. Several concepts were tested as to their influence on hunter attitudes. These included: alienation, status symbolism of hunting success, importance of hunting success to the hunter, peer group interest in hunting, and the influence of the mass media. The greatest influence came from primary social group influences and not from secondary influences or the mass media. Hunters' knowledge of biological and ecological information was not a good predictor of support of or opposition to policy. (See Moncrief 1970b. Condensed from *Dissertation Abstracts*.)

KEYWORDS: Administration, Michigan, preferences, either-sex hunt.

629. ________
1970b. An analysis of hunter attitudes toward the State of Michigan's antlerless deer hunting policy. Mich. Dep. Nat. Resour. Res. Dev. Rep. No. 209, 7 p.

Interviews with 398 hunters from three Michigan counties indicate there were differences in the degree of support of and opposition to the policy of antlerless deer hunting as the major device for deer population control. Individual attitudes were influenced most by primary social groups such as relatives and hunting companions and not by the mass media or secondary social groups. High socioeconomic status groups tended to support the policy regardless of their area of residence. Opposition was located regionally. Although management knew that deer herds were decreasing, about one-fourth of the hunters believed that the deer herds were increasing. Recommendations include extend public contact in order to avoid misinformation and to encourage support, involve hunters in certain management activities, inform employees of reason behind official position of the Department of Natural Resources, establish contact with important leaders of the State, and work more closely with legislatures which nominally oppose game policies.

KEYWORDS: Michigan, big game, management, preferences, administration.

630. Monroe, Warren L.
1968. The legislator and the sportsman. 48th Conf. West. Assoc. State Game Fish Comm. Proc. 48: 142-151.

Paper presents a general procedure for seeking legislation. Organized sportsmen who want their legislative program backed by a majority of the legislature need full support from their State commission and the united and agressive support of their own members.

KEYWORDS: Nevada, legislation, clubs.

631. Moody, Raymond D.
1959. Public recreation on private lands in the southeast. 13th Conf. Southeast. Assoc. Game Fish Comm. Proc. 13: 50-54.

Results of a nationwide survey of recreational facilities on 46 million acres of forest industry lands owned by 455 companies include the following: number providing facilities, number of acres open, number operating public parks, number reporting troubles with recreationists, and number allowing hunting and fishing.

KEYWORDS: Resource use, landowner-private, fishing, surveys.

632. More, Thomas Alastair
1970. Motivational attitudes of licensed Massachusetts hunters. M.S. thesis, Univ. Mass., 50 p., illus.

A mail questionnaire was sent to 618 Massachusetts hunters, and three mailings produced a 69.7-percent return. A sample of nonrespondents was contacted by telephone. Using factor analysis on 52 attitude questions, seven mathematically independent factors appeared. The Likert Scale type questions were answered on a scale ranging from strongly disagree to uncertain to strongly agree. Hunters showed positive attitudes toward the "aesthetics," "communality," and "challenge" factors while they were negative toward a "familiarity" factor. "Pioneering" and "kill" factors were identified by factor analysis, but these were not considered important by hunters. Expected "spartanism" and "escapism" factors did not show up mathematically in the analysis.

KEYWORDS: Benefits, Massachusetts, characteristics.

633. Moreland, Raleigh
1962. Are present-day game management regulations and controls necessary? 42d Conf. West. Assoc. State Game Fish Comm. Proc. 42: 264-266.

Management and biological factors necessary for the proper harvest of game show that it is impossible to establish seasons which are not encumbered by complex regulations and controls.

KEYWORDS: Management, legislation.

634. Morris, Steven
1962. They're killing off the eagle. Am. For. 68(8): 5, 51, illus.

Unprotected by law, disgraced by myths, the golden eagle is hunted ruthlessly.

KEYWORDS: Predator.

635. Morse, William B.
1968. Wildlife law enforcement 1968. 48th Conf. West. Assoc. State Fish Game Comm. Proc. 48: 683-685.

A compilation of wildlife law enforcement data includes records of arrests, convictions, fines, basic demographic and job characteristics of conservation officers, and percent of time spent in law enforcement, game management, safety, education, public relations, and other jobs. Data are tabulated for every State in the Union. It is recommended that the study be repeated in 1973 to establish trend information, that national standards should be set for law enforcement records, that each State continually evaluate and improve its enforcement program, and that universities conduct enforcement research.

KEYWORDS: Enforcement, surveys.

636. Mosby, Henry S.
1950. Cooperative wildlife management on the Virginia State Forests. J. For. 48(10): 700-702.

Agreement between two independent public agencies on general policy for wildlife management on publicly owned forest areas is often the first and most difficult administrative problem in securing intelligent wildlife

management. The Virginia plan of cooperative wildlife management proves such cooperation is possible. The law of diminishing returns, normally a satisfactory harvest limit, is disrupted by relentless pursuit for trophy animals. Wildlife harvest is facilitated by supervising hunting. Data on hunter use of these forests for the period 1940-45 indicate an average of about 130 hunters per wild turkey killed and one bagged turkey per 800 acres. Cost to the program is $0.45 per hunter-hour.

KEYWORDS: Management, Virginia, upland game birds.

637. Moss, A. E.
1942. Income possibilities from a small artificial pond in eastern Connecticut. J. Wildl. Manage. 6(2): 141-146.

A dam erection in 1922 changed a bog into a flood pond where animals, fish, and vegetation could be observed. Values of muskrats, mallards, frogs, fish, plants, and recreation are discussed. An estimated $10 per acre represents the minimum obtainable income of a pond for the crops mentioned.

KEYWORDS: Economics, Connecticut, management, benefits.

638. Moss, William T., and Stephen C. Lamphear
1970. Substitutability of recreational activities in meeting stated needs and drives of the visitor. Environ. Educ. 1(4): 129-131.

Article explores the interrelationships between personality, motives, and recreation activities. Findings show many males list hunting and fishing whenever they are questioned about hobbies or leisure activities, campers and hunters are more traditional than nonparticipants in these activities, hunting and fishing might well substitute for one another, hunting and fishing were negatively correlated with a need to "give in," and hunting was positively correlated with dominance.

KEYWORDS: Non-consumptive use, fishing, preferences, benefits.

639. _________ Lois Shackelford, and G. L. Stokes
1969. Recreation and personality. J. For. 67(3): 182-184.

Two studies involving 437 University of Georgia undergraduates show recreational activities as behavioral expressions of basic personality and suggest the feasibility of further, more refined research. Analysis of variance was used to test relationships between standard questionnaire personality tests to measure "traditionalism," "dogmatism," and "rigidity" and five categories of recreation: camping, hunting, fishing, other forest related activities, and non-forest related activities. An intelligence test on group showed a negative correlation and traditionalism. Hunters were more traditional and dogmatic than nonhunters. Dove hunters and fishermen who use live bait were less rigid than nonparticipants in these activities. (References, 6. For more thorough treatment of these data, see Master's thesis of Stokes 1966.)

KEYWORDS: Fishing, research methods, characteristics, preferences.

640. Motl, Laurence F.
1963. Conservation behind the iron curtain. Wis. Conserv. Bull. 28(1): 24-26, illus.

Russia's conservation problems are primarily concerned with the provision of bare necessities such as water, paper, salt, and food for man. There is no general hunting or fishing, little tourism, and no comparable State or National Parks.

KEYWORDS: Russia, conservation, fishing.

641. Mullen, Patrick Borden

1968. The function of folk belief among Texas coastal fishermen. Ph.D. diss., Univ. Tex., 198 p.

Two basic kinds of traditional folk belief, magic and pragmatic, reveal many insights into the society, culture, and individual personalities of Texas coastal fishermen. Magic beliefs (supernatural and nonrational in concept) and pragmatic beliefs (based on empirical observations of nature) have important instrumental, psychological, and sociological functions. An instrumental function is served when a belief seems to work by bringing about a direct result. A psychological need is fulfilled when beliefs relieve the anxiety associated with a fisherman's uncertain and hazardous existence. Sociological purposes are achieved by beliefs which reflect or implant society's values. As a result of the encroachment of science and technology, skepticism and rationalization surround the beliefs, and "dissonance" has arisen between the fisherman and modern society. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Fishing, folklore, Texas.

642. Murie, Olaus J.

1947. The firing line. Am. For. 53(9): 392-394, 422, illus.

Article describes several examples of mass killing of big game resulting from problems of mismanagement, overpopulation of game, and the concept of sportsmanship.

KEYWORDS: Historical value, big game, management.

643. ________

1954. Ethics in wildlife management. J. Wildl. Manage. 18(3): 289-293.

Wildlife management has the responsibility to move beyond the maintenance of sport hunting. Examples of poor hunter attitudes support this. Quotations from Aldous Huxley, Aldo Leopold, and Robert Patterson support new goals for wildlife management. Two approaches reflecting wildlife ethics are: (1) "nature has a right to exist" for its own sake, and (2) university training should stress the philosophical as well as the technical aspects of wildlife management.

KEYWORDS: Philosophy, management, profession.

644. Murphy, Dean A.

1965. Effects of various opening days on deer harvest and hunting pressure. 19th Conf. Southeast. Assoc. Game Fish Comm. Proc. 19: 141-146, illus.

A weekend opening can concentrate hunting pressure when needed but may detrimentally reduce the deer herd. A Friday opening results in two consecutive opening days, and an increase in hunting pressure. Opening the season on Monday will spread hunter pressure over a longer period of time.

KEYWORDS: Management, crowding.

645. Murphy, Robert Cushman

1956. John James Audubon (1785-1851): an evaluation of the man and his work. N.Y. Hist. Soc. Q. 40(4): 315-350, illus.

This biographical work reports on the famous naturalist whose portfolio, *The Birds of America*, in 1827 brought him public acclaim. Included are:

a general description of his life; his single-minded ambition to study birds; a discussion of his ornithological and natural history studies of alligators, snakes, and birds; the development of his artistic talents; his concept of nature; his change from an avid hunter to that of a man conscious of man's blighting effect on the pristine world; and his role as a natural, gifted philosopher.

KEYWORDS: Historical value, biography, non-consumptive use.

646. Murray, T. B.
1948. Problems involved in securing proper hunter distribution. 28th Conf. West. Assoc. State Game Fish Comm. Proc. 28: 69-70.

The following hunter distribution factors are discussed: terrain, roads, trails, weather, time of hunt, season length, packers, guides, outfitters, regulation by game sex, and publicity.

KEYWORDS: Crowding, management, access, guide.

N

647. Nagel, W. O.
1948. Never had it so good! Wis. Conserv. Bull. 13(9): 12-14, illus.

The idea of super sport, or the return to the fabled "good old days," indicates a lack of perspective which blocks sensible wildlife management. Although there is less game of some species, there is much more of others, and all game is more readily available. Today, recreational sport is the only justifiable basis for hunting and fishing.

KEYWORDS: Fishing, non-consumptive use, folklore.

648. National Shooting Sports Foundation, Inc.
1960. How to start a gun club. 24 p., illus. Sporting Arms Manuf. Inst., New York.

The booklet provides a record of the typical questions and problems which confront sportsmen seeking more and better shooting sport through gun clubs. It gives reliable answers and solutions to the following problems: organization, cost of land acquisition, insurance, publicity, membership, facilities, shooting games, management, clubhouse layouts, and gun club constitution and bylaws.

KEYWORDS: Clubs.

649. ________
1971a. The hunter and conservation. 23 p., illus. Nat. Shooting Sports Found., Riverside, Conn.

Booklet outlines how hunters can favorably influence conservation through sportsmen's organizations, conservation of endangered species, financial support, education about wildlife populations, and introduced species.

KEYWORDS: Conservation, economics, clubs, historical value.

650. ________
1971b. A compilation of the Federal Gun Control Act of 1968. 60 p., illus. Nat. Shooting Sports Found., Riverside, Conn.

Included are amendments to the Act, the rules and regulations promulgated by the U.S. Department of the Treasury for the administration of the Act, industry circulars, questions and answers about the operation of the Act, and other pertinent material.

KEYWORDS: Legislation, equipment.

651. National Wildlife Federation
1971. Hunters and conservationists share goals. Nat. Wildl. 9(6): 18-19.

Presented are official policy statements on hunting by the following conservation organizations: The National Audubon Society, The Wilderness Society, The Wildlife Society, The Izaak Walton League of America, The American Forestry Association, The Sierra Club, and The National Wildlife Federation. All of them approve of sport hunting regulated by scientific game management practices.

KEYWORDS: Conservation, administration, clubs.

652. National Wildlife Staff

1965. Guns, laws, rights, and you. Nat. Wildl. 3(3): 4-7, illus.

Arguments are presented for and against guns and gun laws. Statistics are included on gun ownership, deaths from guns, and crime rates. Conclusion is that laws should be aimed at illegal firearms use and not at the guns themselves.

KEYWORDS: Legislation, accident, equipment.

653. Naylor, A. E.

1963. A report of progress on hunting and fishing access on military lands. 43d Conf. West. Assoc. State Game Fish Comm. Proc. 43: 98-101.

Paper explores action taken, problems encountered, and accomplishments experienced by the California Department of Fish and Game while implementing Federal laws and directives relative to military installations. In general the military agencies have shown a willingness to provide and sustain fish and wildlife.

KEYWORDS: California, access, fishing, landowner-private, military.

654. Nelson, Jan Alan

1964. A critical edition of the *Livro De Citraria*. Ph.D. diss. Univ. N.C., 220 p.

Falconry literature and medieval falconry are included. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Falconry, Portugal, historical value.

655. Nelson, Noland F.

1959. History of waterfowl hunting in Utah. 39th Conf. West. Assoc. State Game Fish Comm. Proc. 39: 233-236, illus.

Paper reviews laws, wetland acquisitions, waterfowl kill, and basic waterfowl hunting regulations in Utah from 1876 to 1958.

KEYWORDS: Historical value, Utah, waterfowl.

656. Neubrech, Walter

1961. Effects of unrestricted Indian hunting and fishing to State wildlife programs. 41st Conf. West. Assoc. State Game Fish Comm. Proc. 41: 250-254.

Paper reviews court cases concerning Indian hunting and fishing privileges. Confusion and lack of authority exemplify the need for Federal legislation.

KEYWORDS: Legislation, Federal-State jurisdiction, fishing, native claims, law violation.

657. Nobe, Kenneth C., and Alphonse H. Gilbert

1970. A survey of sportsmen expenditures for hunting and fishing in Colorado, 1968. Colo. Div. Game Fish Parks Tech. Publ. No. GFP-R-T-24, 83 p., illus.

A mailed questionnaire to 7,478 Colorado hunting and fishing, resident and non-resident license buyers yielded return of 71.8 percent. To

supplement this, data were used from two 1966-67 surveys. Socioeconomic data on resident sportsmen resulted from interviews with 1,865 sportsmen and a mailed questionnaire to 2,335 non-resident sportsmen (73.7-percent return) gave additional socioeconomic data. The average resident sportsman earns $12,000 annually, is 43 years old, has finished high school, and was employed as a professional or skilled craftsman. The average nonresident earns approximately $10,000 annually, has had 13 years of formal education, is 40 years of age, and was a professional or skilled craftsman. The average resident had hunted or fished in Colorado for 15 years and devoted 12 days to either sport in 1966. Nonresidents also devoted 12 days to either sport. Satisfaction with the most frequented county was expressed by 87 percent and 70 percent of the resident and non-resident respondents, respectively. Sportsmen wanted more information on available hunting and fishing areas and improvements in camping facilities. Lack of game or fish dominated reasons for not planning to return. In 1968, Colorado sportsmen spent $237,374,143 on goods and services in connection with hunting and fishing. Residents spent 75.8 percent of this and nonresidents, the other 24.2 percent. Fishermen had the highest per capita expenditure among resident sportsmen ($370.50); among nonresidents, elk hunters had the highest ($415.21).

KEYWORDS: Fishing, economics, Colorado, resident vs. nonresident, characteristics, preferences.

658. Noonan, Helen
1958-59. The shooting preserve in New York. N.Y. State Conserv. 13(3): 4-5, illus.

Article discusses New York's shooting preserve system, how it has evolved, and steps to take for operating a private shooting preserve.

KEYWORDS: New York, refuge, historical value, management.

O

659. Ogilvie, Philip W.
1969. Making the most of our zoos. Parks Rec. 4(1): 32-34, 50, illus.

Zoos justify their existence by their role in conservation, research, and education.

KEYWORDS: Urban wildlife, education, research needs, non-consumptive use.

660. Olsen, Jack
1961. They kill them with kindness. Sports Illus. 15(2): 46-56, illus.

Trophy hunting is examined through the eyes of over half a dozen trophy hunters. Hunting satisfactions vary with the hunter, but they include the thrill of searching for and outwitting game, ego-satisfaction and recognition, to do better than the Jones's and collecting for the sake of collecting because it's a basic, fundamental instinct of man. Among sportsmen, the trophy hunter is perhaps the most strongly motivated of all because no frustrations, however tedious, can stay him.

KEYWORDS: Characteristics, benefits.

661. Ormond, C.
1967. A Montana school for guides. Guns Hunting 11(8): 30-33, 67, illus.

Outfitters Guide School is described, including subjects on: horsemanship, guiding, game and animals, fishing, camp routine, safety, botany, general orientation, equipment, and food services. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Education, guide, Montana.

662. O'Roke, Earl C.
1931. What price fishing? Am. For. 37(5): 275, illus.

Article compares costs of non-resident fishing licenses in the various States. Suggests the need for an interstate license.

KEYWORDS: Fishing, license fee, economics, historical value, resident vs. nonresident.

663. Orona, Angelo Raymond
1968. The social organization of the Margariteno fishermen, Venezuela. Ph.D. diss., UCLA, 366 p.

Participant observation over 13 months was used to study Margariteno Island commercial fishermen. Fishermen were low wage-earners organized into independent work units and living in a camp, or *rancheria*. The *rancheria* is the main link between fishermen and the environment and the larger mainland market system. Bound by traditional and environmental forces, coastal fishermen fish at night, 9 months out of the year, with the aid of bio-luminescent plankton. Day fishing is done the remainder of the year because of the reduction of plankton life. The aquatic and terrestrial setting, the family structure, the *rancheria*, the religion, the impact of death on the community, the fiesta system, and the fisherman's relation to the Caribbean are some of the forces characterizing his culture. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Fishing, Venezuela, characteristics, tradition.

664. Osler, P. F.

1958. Observations on the background and prospects for shooting and fishing in North America. 10th Conf. Northeast. Wildl. Trans. 10: 366-373.

The article shows better sport hunting and fishing in a small, densely populated area which practices the free enterprise system of game management than in a vast, still largely unpopulated area such as Canada which operates under the public ownership system. The free, public hunting trend will eventually mean no game for anyone unless we realize that the free enterprise system is the only way.

KEYWORDS: User fee, economics, Canada.

665. Owens, Gerald P.

1964. Income potential from outdoor recreation enterprises in rural areas in Ohio. Ohio Agric. Exp. Stn. Res. Bull. 964, 51 p., illus.

Outdoor recreation enterprises including privately-owned fish ponds, shooting preserves, and trout fishing were inventories in southern Ohio. Financial data including capital investment, income, expenses, net cash income, interest on investment, and returns to family labor and management are given. Comparisons are also made, based on location, organization, structure and type of management, operator characteristics, decisionmaking, governmental aid and regulation, advertising, insurance, season and hours of operation, weekend use and patronage, technical and management problems, sources of capital, plans for expansion, capital requirements, ownership, and labor requirements. Location was the factor determining the size and success of recreational enterprises. Most, however, had received some governmental aid.

KEYWORDS: Ohio, plant and shoot, economics, landowner-private, non-consumptive use.

666. Owens, John R.

1965. A wildlife agency and its possessive public. Inter-Univ. Case Program No. 87, 52 p., illus. Indianapolis, Ind.: The Bobbs-Merrill Co., Inc.

This is a case study of the existing and future programs and plans of the California Department of Fish and Game and the Fish and Game Commissions. Subjects covered include department organization, financial difficulties, policy conflicts, clientele, survey procedures, and implementation of the planned program.

KEYWORDS: Administration, management, California, either-sex hunt.

P

667. Pace, Charles W.

1954. Something to think about. Fla. Wildl. 7(8): 6-8, 30, illus.

The possibilities, advantages,and disadvantages of introducing into Florida a county fishing license are examined--to be required of all persons who fish only in their own county with either a cane pole or artificial fishing equipment.

KEYWORDS: Fishing, Florida, license fee.

668. Page, Warren

1967. Hunting will never be the same. Field Stream 72(5): 62-63, 100-103.

Increased population will have a great effect on the quality of hunting in the years ahead. Drastic changes may occur for hunters in the future, such as shifts in hunting pressures and concentration of some species, with emphasis on quality, trophies, and a whole new concept of game management. Measures which some States have taken to combat increased hunter pressure are described. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Management, crowding.

669. _________ and Ray Camp

1955. Is public hunting doomed? Part III. Field Stream 60(8): 52-54, 83-86, illus.

Population densities and land utilization have increased the hunting pressure in the Northeast. Game is plentiful but land is scarce. Only 5 percent of the National Forest lands lie in this region and they offer only deer and grouse. Waterfowl, the major sport bird, and its habitat are rapidly disappearing. Local farmers are reluctant to host hordes of hunters. For example, Massachusetts has no open public land for hunting. In contrast, New York deer and grouse are easily taken if the hunter is willing to travel upstate for them. But posted land is increasing, especially near large cities. Farmer-sportsman cooperation attempts have failed. Many sportsman groups are leasing land for the exclusive use of those willing to pay. Unless the States can buy and manage more land, public hunting is doomed. Though public pay-preserves are disliked, they do alleviate pressure on the open fields, and their cost is easier to meet than the private preserves. (Also see part I (Anonymous 1955) and part II (Titus and Laycock 1955).)

KEYWORDS: Landowner-private, user fee, administration, surveys, waterfowl, upland game birds, farmer-sportsman relations.

670. Palmer, T. S.

1904. Hunting licenses: their history, objects, and limitations. USDA Biol. Surv. Bull. 19, 73 p., illus.

This is an excellent historical reference which traces all aspects of resident and non-resident hunting licenses from 1691 to 1904 in the United States. Topics presented include: license legislation, market-hunting, fees, details of issue, objective of licensing, limitations of license

systems, enforcement, legality of licensing, and licensing in nine foreign countries. An index is provided and 29 references are listed on non-resident licensing.

KEYWORDS: License fee, historical value, resident vs. nonresident, foreign country-general, commercial hunting, legislation, enforcement, surveys.

671. Palmer, Walter Lawrence
1966. An analysis of the public use of southern Michigan game and recreation areas. Ph.D. diss., Mich. State Univ., 131 p.

Visitor use on public hunting areas as compared with spring and summer use was measured. Personal interviews and questionnaires revealed that daylight use during the 1961-62 hunting season was about 1 million man-hours, hunting pressure was 60 percent greater than in 1955-56, and the kill of game increased 17 percent. Daytime spring and summer use was less than hunting-season use. Of the 4,004 hunters contacted by questionnaire, 98 percent were male, tended to hunt a variety of game rather than one species, were apt to be rural residents, tended to have middle-class incomes, and averaged just under an 11th-grade education. Hunters in certain age classes harvested some game species more intensively than did others. Various hunting habits such as distances traveled, number of days hunted, and problems of access are correlated with socioeconomic factors and place of residence. Differences in some characteristics appeared to exist in a sample of nonrespondents who were interviewed by telephone. Ethnic and socioeconomic factors apparently affect mail-questionnaire response rates. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Characteristics, Michigan.

672. Park, Edwin Clyde
1959. The use of the set camera as a technique in wildlife photography. M.S. thesis, Oreg. State Coll., 87 p., illus.

A set camera is one placed in position so that an animal, by some natural act such as walking along a trail or picking up food, will trip the shutter and take its own picture. The types of equipment investigated and uses described include camera type, film size, lighting including natural, flood, electronic flash, and flashbulbs, triggering devices, lures and baits, and protection and concealment of equipment. Disadvantages of set camera photography include a limit of one photograph per night, the time needed to locate an animal and set equipment, and lack of control in selecting the sex, age, condition, or body position of the animal being photographed. This technique is a last resort to be used when more desired techniques are impractical. Careful selection of triggering devices and baits and location of sets help minimize the problem of photographing the wrong animal species. The main advantage of a set camera is in photographing nocturnal animals. During the 2-year study, 236 sets were made. A total of 48 photographs of animals was obtained, or approximately one photograph for each five sets. However, only 29 were photographs of the anticipated animal. Electric motors recently put on the market allow more than one picture to be taken per night and may be applicable to census work.

KEYWORDS: Non-consumptive use.

673. Parker, Francis W., Jr.
1946. Increased hunting pressure and human welfare. 11th Conf. North Am. Wildl. Trans. 11: 124-127.

Practice and familiarity are the answers to safety problems. Rifle clubs can serve as training centers. Practice should be required before a hunting license is issued. Firearms registration is opposed because it would increase accidents and lead to government confiscation.

KEYWORDS: Crowding, education, safety.

674. Patton, Clyde P.
1963. The role of law enforcement in State game and fish management. 53d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 52: 63-66.

North Carolina's method of enforcement is described.

KEYWORDS: Enforcement, education, North Carolina.

675. Patton, R. D.
1956. The wildlife economic survey and what it means to wildlife management. 46th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 46: 196-200.

Guides for operating policy can be derived from the National Survey of Hunters and Fishermen. Expenditures for hunting and fishing are in a class with expenditures for public utility services and health services. The most important aspects of the sport, however, may be immeasurable. Legislators and others who control the financial support should become aware that wildlife is not solely judged by economic value of the game.

KEYWORDS: Fishing, economics, surveys, management.

676. Pearl, Robert P.
1960. The 1960 national survey of fishing and hunting. 50th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 50: 128-132.

Paper describes plans for conducting a survey of the U.S. hunter and fisherman population to determine incidence of participation, economic value, and demand for hunting and fishing.

KEYWORDS: Fishing, research methods, surveys.

677. Pearse, Peter H.
1969. Toward a theory of multiple use: the case of recreation versus agriculture. Nat. Resour. J. 9(4): 561-575, illus.

Paper addresses the problem of simultaneous and conflicting use of a natural resource. The author develops a theoretical approach to evaluating the recreational value of deer and the value of cattle using the same rangeland. The assumed objective is maximization of resources' contribution to the group in whose interest it is managed. A high level of hunting success means fewer hunters but more total dollar value than a lower success level. Therefore, maintenance of high levels of hunting success makes more valuable use of the game resource. Deer are more valuable than cattle as long as the value lost in cattle is exceeded by the corresponding marginal value gained in deer.

KEYWORDS: Economics, resource use, non-consumptive use.

678. _________ and Gary Bowden

1966. Big game hunting in the East Kootenay. Univ. B.C. 39 p., illus.

Personal interviews were administered to 544 resident hunters, 56 being rejected. Mail questionnaires to all non-resident hunters yielded 381 usable returns (64 percent) and to all 84 licensed guides yielding 29 usable returns (35 percent). In 1964 15,000 hunted in the East Kootenay, spending 147,000 hunter days and harvesting about 14,000 animals. Nonresidents had significantly higher incomes and education than B.C. hunters. Local hunters, residents, and nonresidents spent an average of $8, $14, and $62 per hunter day, respectively. In total they spent more than $2 million in the 1964 season. Average distance traveled to hunt was 35 miles for local hunters, 400 miles for other B.C. hunters, and 1,500 miles for nonresidents. Hunter occupation, duration of hunt, size of party, age, and motivation for the trip are presented. The local guiding industry, which had revenues of nearly $400,000 or an average of $44 per hunter per day in 1964, is the source of much dissatisfaction. Evidence suggests that the usual economic forces that stimulate efficiency in a competitive market are prevented from working by the system of administration.

KEYWORDS: Fishing, harvest statistics, economics, characteristics, Canada.

679. Pearson, T. Gilbert

1935. Our bird treaty with Canada. 27th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 27: 13-21.

Paper describes the long campaign by Senators, naturalists, game managers, and conservationists to persuade the government to assume protection of migratory birds.

KEYWORDS: Historical value, legislation, waterfowl, Canada.

680. Peay, Golden B.

1958. How can the States more adequately enforce the license provisions of nonqualified holders of resident licenses. 38th Conf. West. Assoc. State Game Fish Comm. Proc. 38: 308-309.

Utah's method of enforcement is described.

KEYWORDS: Enforcement, Utah.

681. Peckumn, Jim W.

1958. How can the States more adequately enforce the license provisions of non-qualified holders of resident licenses? 38th Conf. West. Assoc. State Game Fish Comm. Proc. 38: 310-312.

Paper spells out statutory requirements for purchasing a resident hunting or fishing license in New Mexico; outlines the State's method of enforcement; and suggests that an "information card system" on violators be adopted between the States.

KEYWORDS: New Mexico, license fee, enforcement.

682. Peek, J. M.

1966. Comparison of two mid-winter elk hunting seasons, Upper Gallatin Drainage, Montana. 46th Conf. West. Assoc. State Game Fish Comm. Proc. 46: 87-95.

Number of permittees hunting and hunter success were evaluated in relation to hunter origin and weather conditions. Number, sex, age, and location of elk killed were compiled for the two seasons.

KEYWORDS: Harvest statistics, big game, Montana.

683. Peery, Charles H.

1966. Progress report of Virginia's trout fee-fishing program. 20th Conf. Southeast. Assoc. Game Fish Comm. Proc. 20: 346-356, illus.

The first fee-fishing stream in Virginia has been in operation from the first Saturday in April through Labor Day for trout anglers each year since 1964. Results of a fisherman survey cover days of fishing, type of sample, number of previous trips, type of fishing license used, and origin of fishermen. Data comparisons for each year with analyses are included. Also described are stream regulations, facilities, stocking methods, concessions, record-keeping procedures, camping facilities, law enforcement, and cost of operation. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: License fee, fishing, management, characteristics, Virginia.

684. Pelgen, David E.

1955. Economic values of striped bass, salmon, and steelhead sport fishing in California. Calif. Fish Game 41(1): 5-17, illus.

Average expenditures per angler day were determined in 1953 by a questionnaire survey. Striped bass anglers spent an average of $9 per day and the estimated value of this fishery was $18,000,000. Salmon anglers spent an average of $16 per day, and steelhead anglers spent $18 per day. The major expenditures were transportation, food, lodging, services, and supplies. License costs amounted to about 1 percent of the total costs.

KEYWORDS: Fishing, economics, California, benefits.

685. Peterle, Tony J.

1958. Game management in Scotland. J. Wildl. Manage. 22(3): 221-231, illus.

In Scotland, the landowner has exclusive use of his own land, and he considers hunting an asset which can be leased or sold. The landowner also controls seasons, sets bag limits on species not under protection of bird acts, hires game keepers, controls predators, rears pheasants, and drives game to the hunter's guns. Sportsman groups often purchase shooting rights from small landowners.

KEYWORDS: Scotland, landowner-private, management.

686. ________

1961. The hunter--who is he? 26th Conf. North Am. Wildl. Nat. Resour. Trans. 26: 254-266, illus.

A sample of 6,810 Ohio hunting license buyers returned 3,616 mailed survey questionnaires. This preliminary tabulation of data from 200 questions was based on a sample of 1,100 randomly selected returns. The composition of the Ohio hunting population was described, giving age, sex, marital status, education, salary, place of birth, occupation, race, armed forces experience, employment status, and size of family. Information also includes hunter's attitudes, social life, and hunting experience. Possible distinctions between hunter types are briefly stated, and differences between hunters and those who buy a license but do not hunt are suggested. (Also see Yuhas 1962.)

KEYWORDS: Characteristics, Ohio.

687. ________
1967. Characteristics of some Ohio hunters. J. Wildl. Manage. 31(2): 375-389.

Mail questionnaire with 200 questions was sent to 1 percent of Ohio hunters licensed in 1959 and, after the followup letters, received 70 percent return costing about $1 apiece. Regression analysis related hunter characteristics to success and days afield. Interview followup revealed a non-response bias (see Yuhas 1962). Correlations between independent variables forming a 128 x 128 item table matrix and the questionnaire are available on request. Time spent afield and game killed were related to education, occupation, age of initial hunt, and type of hunter. Also, hunters who favor sound biological approach to game management were not typically from rural backgrounds. They typically read wildlife publications and favored firearm training and a three-shell limit for waterfowl hunting. Peterle concludes hunters are a minority that is diminishing as population grows but are a group of increasing importance to the wildlife resource. (Excellent review of other hunter studies with 34 references cited. Analysis and presentation do not do justice to the data available, although this is one of the best studies of hunter characteristics.)

KEYWORDS: Research methods, preferences, characteristics, Ohio.

688. Petersen, Eugene Thor
1953. The history of wild life conservation in Michigan, 1859-1921. Ph.D. diss., Univ. Mich., 342 p.

This historical study attempts to establish the beginning and evolution of the State conservation policy related to wild animals, birds, and fish. Initial impetus for conservation came from sportsmen's groups and later from special interest groups. State action during this period relied on restrictive measures to preserve wildlife, but refuges and species propagation were soon needed. Today Michigan's reputation is evidence of the success of the constructive policies adopted after 1910. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Michigan, conservation, historical value, legislation.

689. Peterson, Fred
1954. John Doe--friend or foe? 34th Conf. West. Assoc. State Game Fish Comm. Proc. 34: 97-100.

Paper suggests that game departments remove restrictive pressures from their public relations men, pay them sufficient funds, and encourage all department workers to seek out the press.

KEYWORDS: Public relations.

690. Peterson, William J.
1969. A literature review on deer harvest. Colo. Div. Game Fish Parks Coop. Wildl. Res. Unit Spec. Rep. No. 22, 15 p.

Two major factors affecting harvest, deer distribution, and hunter distribution are discussed. Deer distribution is influenced chiefly by weather and topography. Distribution of hunters is affected by weather, topography, vegetation density, area accessibility, opening date, season bag limit, and access roads and trails. (References, 180.)

KEYWORDS: Crowding, big game, characteristics, literature.

691. Phillips, F. Donald

1938. Game laws from the judge's viewpoint. 30th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 30: 38-42.

From the earliest traditions, the right to kill wild mammals and birds has been legally controlled by the Nation. American colonists imported English common law; and in the United States, game is controlled by the State. It is the duty of the courts to interpret and enforce hunting and fishing laws. The courts should punish violators but also create a profound respect for the laws to deter further violations.

KEYWORDS: Legislation, historical value, enforcement.

692. _________

1940. The importance of education and law enforcement in wildlife programs. 34th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 34: 51-57.

In order to properly enforce wildlife conservation laws, the public must be educated to realize the importance of wildlife. There must be respect for the laws governing wildlife, love of wildlife, a sense of its value to mankind, and a cooperation--for its protection--between law-enforcement officers, citizens, and the courts. References are made to the Migratory Bird Treaty and the Mexican Treaty.

KEYWORDS: Education, enforcement, legislation.

693. _________

1956. Ownership of wildlife: ancient Athens to America of today. Outdoor Calif. 17(9): 4-5, 12, illus.

The history of ownership of wild game is presented. During Roman times wild game was considered property in common to all the citizens of the state. After the Norman Conquest and before the Magna Charta in England, ownership of wild game was vested in the king. In modern times in the United States, ownership is common among all people, as it was earlier. Individuals may acquire property rights in game only as a matter of privilege, not as a matter of right. The article specifically covers the legal problems of migratory birds of North America and the necessity of treaties and enactment of harvest restrictions.

KEYWORDS: Historical value, waterfowl, legislation, landowner-public, landowner-private.

694. Phillips, John C.

1931. Naturalists, nature lovers, and sportsmen. AUK. 48(1): 40-46.

An analysis is presented of the different mental horizons of ornithologists and sportsmen.

KEYWORDS: Esthetics, fishing, non-consumptive use.

695. Phillips, Paul H.

1965. The economic impact of the Louisiana deer hunter on the communities surrounding the Chicago Mill Game Management area. M.S. thesis La. State Univ., 43 p.

Questionnaires mailed to 2,345 Louisiana deer hunters visiting the 102,000-acre Chicago Mill Game Management area yielded a 60.8 percent response after three mailings, and results were checked with 56 personal

interviews. Data include costs of transportation, lodging, clothing, and equipment. Local hunters spent an average of $13.55 per hunting effort, and "foreign hunters" spent an average of $45.59 per hunting effort. Local hunters' expenditures totaled $69,000 compared with $190,000 for foreign hunters. Author concluded that hunting could become the primary cash crop of the local area and that deer hunter expenditures in Louisiana approach $1 million annually.

KEYWORDS: Economics, Louisiana, big game.

696. Pimlott, D. H., C. J. Kerswill, and J. R. Bider
1971. Scientific activities in fisheries and wildlife resources. Sci. Counc. Can. Spec. Study No. 15, 191 p., illus.

A study included the application of fisheries and wildlife science, the way agencies and professionals relate to society, and determination of wildlife goals in relation to national Canadian goals. Chapters include social and economic values of fisheries and wildlife. Social values include recreational, therapeutic, artistic, educational, and ecological. Others include the excitement of the chase, the pleasure of sensory enjoyment, and the satisfaction of obtaining trophies. Wildlife is essential to health, to the understanding of man, to teaching ecology and to promoting awareness. The economic impact from angling and hunting comes from food values and from other expenditures such as equipment and lodging. Fishermen spent a total of $188 million in 1961, for an average of $143 per fisherman. Hunters spent a total of $87 million for an average expenditure of $110. The average expenditure per day was $9.50 for sport fishing and $8.16 for hunting. Both federal and provincial resource agencies should support socioeconomic studies of recreational resources.

KEYWORDS: Canada, fishing, administration, economics, benefits.

697. Pinkas, Leo, James C. Thomas, and Jack A. Hanson
1967. Marine sportfishing survey of southern California piers and jetties, 1963. Calif. Fish Game 53(2): 88-104, illus.

The magnitude and significance of sport fishing activities was determined by a creel census. Data show that a minimum of 5.1 million man-hours of fishing was expended in catching 1.86 million fish from February to December 1963. The catch consisted of 49 species of fish, and well over 60 percent of the activity and catch occurred from piers. Pier development should continue, and periodic surveys should determine sport fishing activities for the entire California coast.

KEYWORDS: Fishing, harvest statistics, California.

698. Pollock, Norman Hall
1968. The English game laws in the nineteenth century. Ph.D. diss., Johns Hopkins Univ., 416 p.

After 1671, the English aristocracy developed a stringent code of laws to protect game and to make shooting the exclusive preserve of those owning land. Thomas Paine and other radicals questioned the aristocracy's claim to a monopoly of game. After 15 years of protracted debate, the Game Act of 1831 eliminated the property qualification and made shooting available to anyone who secured a license. Allegations that game damaged farmers' crops were as much exaggerated as the reformers' oversimplification that the game laws alone caused rural crime. Conservatives predicted that without

cruel deterrents game would be annihilated and country gentlemen driven off their estates. These myths had the power to arouse public opinion and were used as vehicles for grievances less easy to articulate. A decade later, radicals made the game question part of the larger land question and sought to win the farmers' allegiance by advocating abolition of the game laws. Farmers used the game issue as a vehicle for other stresses in the landlord-tenant relationship. The war of 1914 ended the luxurious sport of the previous decades, and field sports, stripped of their worst abuses, remained an important feature of English country life. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Historical value, folklore, England, legislation.

699. Pomeroy, Kenneth B.
1961. Recreation trends in the South. Am. For. 67(6): 44, 46-48.

Review of current trends in outdoor recreation in the South indicates that hunters, fishermen, and other recreationists can exert considerable influence upon the future of southern forestry.

KEYWORDS: Fishing, non-consumptive use.

700. Poole, Daniel A.
1971. Insuring the future of hunting and fishing. Wildl. Soc. News 136: 45-46.

To insure the future of hunting, more attention must be given to the public-acceptance factor. Four avenues of approach are discussed: better service to hunters, greater personal responsibility by the sportsman, better understanding of and service to landowners by both the wildlife agency and the sportsman, and better understanding within the profession as to what constitutes sport hunting.

KEYWORDS: Fishing, farmer-sportsman relations, public relations.

701. ________
1972. How to insure the future of hunting and fishing. Colo. Outdoors 21(4): 1-4.

Public acceptance has much to do with the future of hunting and fishing, yet wildlife agencies do little work in this area. Better attention could be given to this public acceptance factor by: better service to hunters by State game departments, better discharge of personal responsibility by the sportsman himself, better service to landowners by both the wildlife agencies and sportsmen, and a clearer understanding among wildlife professionals that more hunting is not necessarily better hunting.

KEYWORDS: Administration, antihunting, public relations, communications, farmer-sportsman relations.

702. Powell, Lawrence E.
1958. Hunter report cards versus questionnaires. 38th Conf. West. Assoc. State Game Fish Comm. Proc. 38: 235-238.

Paper favors the questionnaire method over the hunter report card system because the former is statistically accurate.

KEYWORDS: Arizona, research methods.

703. Powers, James F.

1960. The commissioner's responsibility in keeping private lands open to public hunting. 40th Conf. West. Assoc. State Game Fish Comm. Proc. 40: 94-97.

Game commissioners are responsible for keeping private lands open for public hunting. To properly manage wildlife resources, periodic harvests must be taken on private as well as public land.

KEYWORDS: Landowner-private, access, management.

704. Prendergast, Joseph

1962. What people want for recreation. 27th Conf. North Am. Wildl. Nat. Resour. Trans. 27: 59-66.

Following are factors to consider for recreation development. People tend to choose recreation that is already familiar to them; they will choose a new and untried recreation activity if it captures their imagination; and a certain proportion of the population seeks activities which challenge their skill. The playground leader, wildlife manager, forester, and wilderness ranger must provide leadership to Americans so they can realize opportunities in recreation.

KEYWORDS: Non-consumptive use, resource use, preferences.

705. ________

1966. Hunting and fishing recreation on State and Federal Park lands. 56th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 56: 142-145.

The National Park System is authorized by law to prohibit public hunting on Park lands, but fishing is allowed. Hunting ranges are under the jurisdiction of the Forest Service and Bureau of Land Management, and they comprise approximately 70 percent of the public domain. Hunting is also permitted in most national seashores, rivers, and national recreation areas. The policy on hunting in State parks and recreation areas varies widely. Although hunting may have to conform with future land usage problems, it is now a form of recreation and should be taken into account when planning park and recreation areas.

KEYWORDS: Landowner-public, management, fishing, resource use.

706. Prichard, Albert T.

1958. Relative importance of biological recommendations and public opinion in setting hunting and fishing seasons. 38th Conf. West. Assoc. State Game Fish Comm. Proc. 38: 151-153.

It is important to have biological inputs as well as public opinion, but biological considerations must not weaken under group pressures.

KEYWORDS: Public relations, management, legislation.

707. Public Land Law Review Commission

1970. Fish and wildlife resources, p. 157-175. *In* One third of the Nation's land. 342 p., illus. Washington, D.C.: Supt. Doc.

This report to the President and to Congress covers an evaluation of publicly owned lands and the natural resources on those lands. Chapter 9, "Fish and Wildlife Resources," concentrated on 20 States, each with public lands exceeding 6 percent of its area. Eight recommendations covering

fish and wildlife on Federal lands are discussed: (1) Statutory authority should be given to Federal officials for land use decisions such as restrictive harvest regulations and controlling user density and dispersions, (2) Uniform State-Federal cooperative agreements should be formed for fish and wildlife programs, (3) Objectives of wildlife management should be required to minimize conflicting land and resource uses, (4) Guidelines are needed for minimizing conflicts between fish and wildlife and other land uses and values, (5) Zoning to identify key habitat should designate dominant use of fish and wildlife, (6) A Federal land use fee should be charged for hunting and fishing, (7) The States and Federal Government should share financial burden of fish and wildlife programs such as habitat improvement, population surveys, control, and stocking, and (8) State policies should be abolished which discriminate against non-resident hunters and fishermen using Federal lands.

KEYWORDS: Landowner-public, management, surveys, Federal-State jurisdiction, resource use, administration.

708. Pulling, A. V. S.
1928. The importance of wild life and recreation in forest management. J. For. 26(3): 315-325.

The attitude of the forestry profession toward sporting and recreational uses of the forests has been one of mere toleration. Professional foresters must recognize that the public interest in wildlife and recreation is superior in some areas to wood production and may produce an income and pay taxes on uncommercial forests. Many examples illustrate the low interest rates from timber growing and compare these with the values obtained from recreation and wildlife.

KEYWORDS: Economics, historical value, non-consumptive use, resource use, benefits.

Q

709. Quigley, Merle J.
1966. A survey of Idaho Wildlife Federation affiliates. M.S. thesis, Utah State Univ., 125 p., illus.

A personal interview survey of 63 active Idaho conservation clubs (includes hunting, fishing, and sportsman's clubs) that were affiliated with the Idaho Wildlife Federation determined how active the clubs were, what projects they sponsored, what factors were responsible for their continuing activity, and whether clubs attempted to make other people aware of conservation problems. Data were analyzed by mechanical edge-punch-sort system, then placed on reciprocal relations tables. Findings show that retired people exert the most leadership on clubs; a positive relationship exists between number of years an officer has been a club member and the success of the club; club activities are largely consistent with club purposes; area population had little effect on club size; clubs with hunting, fishing, or conservation as major purposes have the most members and the highest number of completed projects; location of the club meetings affects club success; club success was highly related to amount of communication with the parent State organization; and landowner-sportsman relations were a major public relations project for most clubs.

KEYWORDS: Idaho, conservation, clubs.

R

710. Rachford, C. E., Seth Gordon, and Elliott S. Barker
1935. National Forest regulation G-20A. J. For. 33(1): 28-33.

Three articles briefly discuss the workability and desirability of Forest Service control rather than State control of fish and game protection. Rachford explains the regulation, Gordon addresses himself to "Is it wise? Will it stick?" and Barker gives "A game official's views of regulation G-20A."

KEYWORDS: Federal-State jurisdiction, legislation, historical value.

711. Rakestraw, Lawrence
1955. A history of forest conservation in the Pacific Northwest, 1891-1913. Ph.D. diss., Univ. Wash., 358 p.

Shortly after the Civil War, scientists, recreation and esthetic groups, and men disturbed by public land law violations of economic and political interests became interested in preserving forest lands. Between 1891 and 1897, seven reserves were set aside in the Pacific Northwest as the result of legislation permitting the President to establish forest reserves. Because the Federal forests were under three Bureaus with conflicting jurisdiction, the years 1897 to 1905 were spent developing an efficient forest administration. After 8 years, the reserves, or National Forests, were placed under the Forest Service with Gifford Pinchot heading the Bureau. During those years, problems, including grazing policy and reduction and

creation of reserves, were met. Administrative decentralization of the National Forests began in 1905 and was completed in 1908. District foresters instituted professionalism and established first timber management and grazing policies. The period 1905 to 1913 saw the rise of a coalition of conservative politicians and land looters along with guild associations consisting of State, Federal and private timberland owners. By 1913 the Northwest set a model for the rest of the country in cooperative fire protection and was ready to extend its work into other forest problems. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Historical value, conservation, surveys.

712. Ramsey, Bob
1955. Texas holds second antlerless deer hunt. Tex. Game Fish. 23(8): 2-3, 26-27, illus.

A total of 3,329 antlerless deer, part of an estimated 9,000 surplus deer, were killed during 1954 in a special "doe" season.

KEYWORDS: Big game, Texas, either-sex hunt, harvest statistics, management.

713. ________ and Eugene Walker
1954. Take 'em (like this) or leave 'em (like this). Tex. Game Fish. 12(7): 4-6, 20-21, 27-28, illus.

Article describes Texas' first antlerless deer hunt designed to improve and strengthen deer herds and provide hunting of game which would otherwise die on overpopulated ranges.

KEYWORDS: Texas, either-sex hunt, management, harvest statistics, big game.

714. Randle, Thurman
1945. The semi-automatic as a sporter. 10th Conf. North Am. Wildl. Trans. 10: 70-74.

Many hunters become used to semiautomatic and full automatic weapons from army experiences. The name "automatic" is a misnomer when applied to hunting because true automatic actions are outlawed. The confusion between the two types of weapons presents problems and has often caused the semiautomatic gun to be banned from hunting. Misuse of the semiautomatic could be curtailed by limiting the magazine to three-shot capacity. Several military weapons are not considered sporting arms, but if a gun accepts a properly designed sporting cartridge of adequate power, is accurate at sporting ranges, and its action is dependable, it will be just as sporting as its owner.

KEYWORDS: Equipment, safety, historical value.

715. Rawley, Edwin V.
1952. A survey of extension work in wildlife management and the development of a guide to wildlife extension work in Utah. M.S. thesis, Utah State Agric. Coll., 101 p., illus.

Data were obtained by personal interview of 85 Utah farmers and 23 others, including fur dealers, sportsmen, youth leaders, fur farm operators, nurserymen, hatcherymen, and locker plant operators to determine the need for a wildlife extension service in Utah. In addition, mail questionnaires gave information from 28 Utah county extension agents, seven State wildlife conservation organizations, 48 State cooperative agricultural extension

services, and nine national wildlife conservation organizations. The data show that 28 States have been requested to add a wildlife specialist to their staff, while 42 States have been asked to solve problems that could be handled by a wildlife specialist, and 39 States have been asked to supply materials that could be handled by a wildlife specialist. These findings suggest that wildlife specialists are needed "in most of the states." The author develops a guide to be used by Utah wildlife extension specialists to integrate wildlife conservation interests with other agricultural extension activities. (References, 42.)

KEYWORDS: Surveys, education, conservation.

716. Redmond, Howard R.
1953. Analysis of gray squirrel breeding studies and their relation to hunting season, gunning pressure, and habitat conditions. 18th Conf. North Am. Wildl. Trans. 18: 378-389, illus.

A questionnaire census of Mississippi game kill showed that over 79 percent of the total license holders in Mississippi hunt squirrels. A 3-year average of squirrel hunters' bag checks revealed that the average time spent per hunt was 2.8 hours, 75 percent of the total squirrel hunters were still-hunters, 25 percent used dogs, and the average kill per hunt was 2.2 squirrels.

KEYWORDS: Harvest statistics, Mississippi, small game.

717. Reed, Jim
1961. Wildlife is wealth. Fla. Wildl. 14(9): 11-13, 34, illus.

Brief outline is given of the economic and recreational value of Florida's wildlife.

KEYWORDS: Florida, non-consumptive use, fishing, economics, characteristics, benefits.

718. Reeves, John Henry, Jr.
1960. The history and development of wildlife conservation in Virginia: a critical review. Ph.D. diss., Va. Polytech. Inst., 345 p.

Precolonial forest and field conditions were suitable for elk, bear, turkey, grouse, squirrel, and buffalo; habitat conditions were poorer for rabbits, deer, and quail. With the introduction of agriculture in the colonial era, habitat improved for quail and rabbits, but deer numbers were so reduced that legislation was enacted to protect this species. Virginia's postcolonial period 1778-1915 was one of extravagance. As a result of agricultural expansion, lumbering, the Civil War, and market hunting, buffalo and elk were extirpated from the State. Refuges were developed and legislation enacted, but there was little hope that the game animals could be perpetuated. The laws intended only to prolong wildlife existence. During 1916-58, wildlife management practices improved greatly and appear to be satisfactory for deer, bear, grouse, quail, rabbit and squirrel; only the turkey is decreasing. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Historical value, Virginia, management, conservation.

719. Reid, Leslie Merle
1963. Outdoor recreation preferences: a nationwide study of user desires. Ph.D. diss., Univ. Mich., 299 p.

Characteristics of recreation visitors, with particular attention given to the preferences, desires, and dissatisfactions, were reported for visitors at 24 selected public, non-urban, outdoor recreation areas distributed throughout the United States. A self-administered questionnaire yielded information about user socioeconomic data, travel characteristics, activities and facilities used, and opinions of satisfaction and dissatisfaction associated with the visit. Single families predominate on extended vacation trips, and groups of families on shorter trips closer to home. Mileage from home rather than the kind of area largely determines the use made of recreation areas. Relaxing is an important element in most visits. National Parks had the highest rate of camper dissatisfaction. Restrooms generally received the most criticism of all facilities, and roads and parking areas were generally acceptable. Two categories of dissatisfaction were: conditions beyond the control of management such as bad weather, and conditions which management could control such as crowding, unsanitary or littered conditions, and pricing of sale or rental items. Visitor satisfactions are determined by the amount of personal enjoyment resulting from the visit. User desires alone are inadequate for determining desirable recreational development and administration. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Resource use, preferences, administration, surveys, characteristics.

720. Reinecker, Tom
1968. Unlawful purchases of resident licenses by nonresidents. 48th Conf. West. Assoc. State Game Fish Comm. Proc. 48: 667-674.

Paper includes outlined procedure for Idaho conservation officers to follow in handling all license applications, plus ideas and recommendations for other States. Questionnaire sent in 1967 to 12 western States reveals only Idaho was using a separate license application for residents and nonresidents.

KEYWORDS: Idaho, license fee, resident vs. nonresident, administration, law violation.

721. Rettinger, D. O.
1961. Hunter management on Federal lands in Illinois. 51st Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 51: 50-56.

The following three programs are employed in Illinois on 40,000 acres of the Mississippi River fish and waterfowl management areas: (1) restricted public hunting areas with intensive hunter use; (2) isolated open public hunting areas; and (3) small waterfowl refuges. Hunter control laws are flexible and permit annual program changes. A brief history of the areas illustrates the conditions which necessitated basic hunter-management controls. Blinds are no longer monopolized, and enforcement problems have decreased. Hunter education, sportsmanship, and hunter restrictions are helping to improve hunter quality.

KEYWORDS: Management, Illinois, waterfowl, legislation.

722. Reynolds, Carlos
1964. Florida Game and Fresh Water Fish Commission public relations for the wildlife officer. 18th Conf. Southeast. Assoc. Game Fish Comm. Proc. 18: 576-581.

Paper tells how to gain public acceptance and favor through sound public relations.

KEYWORDS: Florida, public relations, profession, enforcement.

723. Reynolds, Hudson G.
1971. Game production and harvest in Czechoslovakia. J. For. 69(10); 736-740, illus.

Game keeping in Czechoslovakia is similar to that in other countries of central Europe because of the common aristocratic origin of the hunting tradition. Ownership of game by the State resembles that of Poland, but differs from West Germany and Austria where game belongs to the landowner. Regardless of ownership, the basic objective of game management remains the same--maintenance of quality game populations in harmony with forestry and agriculture. Game management is intensive, including plans for carefully detailed harvests and strict hunter qualification. Intensified game management in America will require greater direct and indirect participation by the hunter in environmental concerns at local and national levels if the European experience is used as a guide.

KEYWORDS: Czechoslovakia, management.

724. Rice, Alfred W.
1956. A big step forward. Wis. Conserv. Bull. 21(10): 3-6.

Article outlines recommendations and regulations of farmer-sportsman program.

KEYWORDS: Wisconsin, farmer-sportsman relations.

725. Richards, Edward C. M.
1932. European game management as suggestive of American procedure. J. For. 30(8): 948-950.

Public hunting in Europe differs from that known in America. The hunter may not keep the game he shoots. Hunting and game management are controlled by foresters who have learned that silviculture and game production must be coordinated. Agreements between timber and game interests in America should follow the European example. American game is owned and administered by the States, and forest considerations and conflicts have not yet been given sufficient thought except where damage has resulted from overpopulation by game.

KEYWORDS: Rumania, management, Switzerland.

726. Richards, Jack Arthur
1968. An economic evaluation of Columbia River anadromous fish programs. Ph.D. diss., Oreg. State Univ., 286 p.

Anadromous fish of the Columbia River compete with irrigation, flood control, navigation, and other products requiring construction of dams that blockade essential fish migration routes. Costly passage facilities at the dams prevent total blockage of the lower river, and supplemental projects, such as fish hatcheries, at least partially replace lost productivity. Benefits of these fish, resulting from commercial, sport, and Indian fishing, cannot be directly measured through market prices and must be estimated. The cost of regulated inefficiency was used to estimate net benefits from commercially caught fish. Transfer costs were used as a proxy for non-existent market prices to estimate the value of sport-caught fish. Past, present, and future program costs and associated benefits indicate that the effort to preserve Columbia River anadromous fish probably could not have been justified by economic criteria in the 1930's when major costs first appeared. The share of this program remaining in 1965 could be justified

on economic grounds if traditional capital costs were used and where alternative investment possibilities were not considered. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Fishing, economics, resource use.

727. Richards, Thomas H., Jr.
1964. The role of private enterprise in providing fishing and hunting recreation in California. 44th Conf. West. Assoc. State Game Fish Comm. Proc. 44: 91-95.

Most of the waterfowl, pheasants, valley quail, doves, and about 35 to 40 percent of the deer in California are found on private lands. Both the landowner and governmental agencies have recognized the importance of game on private lands and have initiated programs that pay the farmer (either through good will, added protection, or money incentives) to develop his lands for wildlife.

KEYWORDS: California, landowner-private, fishing, clubs, waterfowl, big game, economics.

728. Richter, Marcelle Thiebaux
1962. The allegory of love's hunt: a medieval genre. Ph.D. diss., Columbia Univ., 415 p.

A literary type, in which a hunter's quest parallels his amatory worth, survives in eleven old French and Middle High German poems dating from the 13th to the 15th century. Questions crucial to the genre are: How is the hunt situation distorted to be metaphorically useful in representing courtly love, and how does the hunt metaphor alter the concept of courtly love? Presented are hunting practices found in medieval handbooks, investigation of medieval assumptions about hunting, through the images of hounds and stags, and a discussion of allegories specific to each poem. The German allegories feature the quest and sterner aspects of the hunt, while the French allegories preserve pleasant fellowship of hunts and avert the hint of anguish in the quest. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Literature, historical value, Germany, France.

729. Riegel, A. E.
1952. Sportsmen's clubs and their relation to the fish and game departments. 32d Conf. West. Assoc. State Game Fish Comm. Proc. 32: 18-21.

Paper presents the aims and objectives of Montana's wildlife federation and discusses what the biologist has to offer the sportsman.

KEYWORDS: Montana, education, administration, clubs.

730. Riggen, Carl
1962. Hunting and fishing in National Park areas. 52d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 52: 18-20.

Paper suggests that the management of game and fish on National Park lands be turned over to State game and fish commissions.

KEYWORDS: Resource use, administration, Federal-State jurisdiction.

731. Riley, Smith
1920. A national game policy. J. For. 18(8): 767-774.

The forester must direct public thought and guide public action to fix a national wildlife policy. Forest lands, once administered to produce life for the chase, must now produce products of first importance in maintaining human values. America as a nation is commercial, yet human values must stand above property to perfect this commercialism.

KEYWORDS: Philosophy, public relations, administration.

732. Ritter, Charles
1955. What is it worth to you? Wyo. Wildl. 19(5): 32-34, illus.

Relative amounts spent by resident and non-resident big game hunters in Wyoming are listed for 1954.

KEYWORDS: Wyoming, fishing, economics, user fee, resident vs. nonresident.

733. Robel, Robert J.
1960. Detection of elk migration through hunter interviews. J. Wildl. Manage. 24(3): 337-338.

Elk numbers can be better determined by using hunter reports of elk sighted per hour rather than the number killed. Sightings eliminate biases of hunter marksmanship and selectivity. In the interview, hunters reported 2,858 hunter-hours afield. This technique was found acceptable, although frequently obstructed by hunter biases and antagonism toward fish and game departments.

KEYWORDS: Big game, research methods.

734. Roberts, Don
1951. The gates are opening. Fla. Wildl. 5(6): 6-7, 33-35, illus.

Florida's conservation commission opens over a million acres to public hunting for a $5 public area stamp.

KEYWORDS: Florida, access, user fee.

735. Robertson, A. Lee
1959. The hunter safety program in Utah. 39th Conf. West. Assoc. State Game Fish Comm. Proc. 39: 375-378.

Paper describes a Utah survival training program intended to decrease all types of accidents.

KEYWORDS: Utah, safety, education.

736. ________
1964. Survival training, an important part of hunter safety. 44th Conf. West. Assoc. State. Game Fish Comm. Proc. 44: 321-323.

Paper gives brief description of Utah's survival (when lost) program and advice for controlling one's tendency to panic.

KEYWORDS: Education, safety, Utah.

737. ________
1966. Hunter safety classes--a captive audience of tomorrow's sportsmen. 46th Conf. West. Assoc. State Game Fish Comm. Proc. 46: 381-384.

Paper suggests including a presentation of range and wildlife management problems during hunter safety classes.

KEYWORDS: Education, safety.

738. Robson, D. S.
1960. An unbiased sampling and estimation procedure for creel censuses of fishermen. Biometrics 16(2): 261-277, illus.

Article discusses estimation of total catch and total fishing effort by means of individual fisherman interviews and an untested sampling design which provides data for unbiased ratio-type estimates. The proposed plan sacrifices efficiency of operation in the field for complete objectivity in the data. (Includes complex computational procedure.)

KEYWORDS: Harvest statistics, fishing, research methods.

739. Roca-Garcia, Helen
1964. If I were teaching a boy to hunt. Nat. Wildl. 3(1): 32-33, illus.

Train a boy to hunt with his eyes, ears, camera, and field glasses, rather than with a gun.

KEYWORDS: Non-consumptive use, antihunting.

740. Romney, Henry
1960. How to reform hunters. Sports Illus. 13(11): 66-69, illus.

Article describes utilization of the New York Fish and Wildlife Management Act which offers protection and enforcement to landowners who open their land to responsible hunters.

KEYWORDS: Enforcement, New York, farmer-sportsman relations, legislation.

741. Rosasco, M. Edwin, and Elwood M. Martin
1964. Extent to which U.S. waterfowl hunters hunt in States and countries other than those in which they purchase their duck stamps. USDI Bur. Sport Fish. Wildl. Serv., Div. Wildl. Res., Migratory Bird Pop. Stn. Admin. Rep. No. 66, 9 p.

Data were obtained from the 1963-64 National Waterfowl Kill Survey of duck stamp purchasers. Estimates show the numbers and distribution of hunters, by State. The Atlantic flyway leads all others in the proportion of hunters hunting outside their State. About one-half percent of the total duck stamp purchasers hunted in a foreign country.

KEYWORDS: Waterfowl, surveys, resident vs. nonresident.

742. Rose, Philip S. (Chairman)
1939. Farmer-sportsman, a partnership for wildlife restoration. 4th Conf. North Am. Wildl. Trans. 4: 144-200.

Nine authors individually discuss farmer-sportsman relations: Aldo Leopold, Judge Geo. W. Wood, John H. Baker, Walter P. Taylor, Lester MacNamara, Harold Titus, G. W. Bradt, Justus H. Cline, and Walter F. Kirk.

KEYWORDS: Landowner-private, legislation, farmer-sportsman relations, administration.

743. Rose, Thomas E.
1948. The role of the enforcement officer in public relations. 38th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 38: 131-135.

Paper reviews duties and qualifications of the enforcement officer, enforcement-division assistance to management and research, and responsibility of administrator and technician to the enforcement division.

KEYWORDS: Administration, enforcement, Connecticut, profession, public relations.

744. Roseberry, J. L., D. C. Autry, W. D. Klimstra, and L. A. Mehrhoff, Jr.
1969. A controlled deer hunt on Crab Orchard National Wildlife Refuge. J. Wildl. Manage. 33(4): 791-795.

To reduce a high white-tailed deer population on the closed portion of the refuge, a controlled 10-day hunt was held in January 1966. A total of 3,232 Illinois residents hunted 3,919 times and harvested 1,073 deer. An additional 36 wounded and dead animals were retrieved. Methods were employed during the hunt to achieve maximum recreational benefits consistent with the primary objective of controlled herd reduction.

KEYWORDS: Big game, harvest statistics, refuge, Illinois, management.

745. Ruch, James B.
1967. There's one born every minute. 47th Conf. West. Assoc. State Game Fish Comm. Proc. 47: 462-469.

Article criticizes public agencies which advertise and promote sacred hunting and fishing "hot spots" in the name of full natural resources utilization. They are guilty of using education programs to expose good hunting and fishing spots in order to increase tourist revenues. Such promotion is hard to justify on ethical grounds.

KEYWORDS: Public relations, resource use, philosophy.

746. Ruhl, H. D.
1946. Acquisition and management of public hunting grounds. 36th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 36: 98-113, illus.

A survey of public shooting programs in the United States includes the following information: land management activities by public agencies, acreage of public land owned for hunting, number of hunter licenses issued, gun pressure, and regulations.

KEYWORDS: Landowner-public, management.

747. Rutherford, R. M.
1941. Wildlife restoration through State and Federal cooperation under the provisions of the Pittman-Robertson Act. J. For. 39(2): 157-160.

A summary is given of the Pittman-Robertson Act covering: funds, how they are derived and appropriated, design purpose, conditions for participation, land acquisition, land development, and wildlife management research programs of some States. The wide variety of wildlife restoration projects by participating States shows that State and Federal governments can cooperate.

KEYWORDS: Administration, economics, legislation.

748. ________
1950. Federal aid for sport fishing. J. For. 48(12): 891.

Article gives description of the Dingell-Johnson Federal Aid to Fish Restoration Act designed to aid the Nation's 15 million sport fishermen in the same manner that the Pittman-Robertson Act aids nearly 13 million licensed hunters. Funds, apportionments, lines of approvable work, and other features of the act are discussed.

KEYWORDS: Fishing, legislation, economics.

749. Ryan, Pat

1971. ...and a partridge in a palm tree. Sports Illus. 34(2): 44.

A humorous report is given on a serious matter from Cocoa, Florida, on the annual Audubon Society Christmas bird count which for 71 years has encouraged people to count, not kill, the local birds. Bird-counting teams across the Nation compete to observe the greatest number of birds.

KEYWORDS: Non-consumptive use.

750. Ryel, L. A.

1971a. Deer hunter participation survey, 1970. Mich. Dep. Nat. Resour. Res. Dev. Rep. No. 254, 11 p.

A mail questionnaire followed by four followup mailings and a personal contact were used to obtain a 94-percent response rate of 358 deer licensees sampled. Data from the 1970 survey and previous years include: ownership and use of snowmobiles by hunters; opinion on hunter congestion; lodging used; hunting frequency from 1962 to 1968; the number buying regular gun licenses from 1963 to 1968; summary of occupations and ages of hunters; the number purchasing licenses and State park permits; opinion on a proposed combination of bow and arrow and firearm deer licenses; and opinions on allowing a hunter to take two deer in 1 year--one with bow and arrow and one with a firearm.

KEYWORDS: Michigan, big game, preferences, characteristics, archery.

751. ________

1971b. Deer hunters' opinion survey, 1970. Mich. Dep. Nat. Resour. Res. Dev. Rep. No. 255, 15 p.

Hunter mail surveys returned from 1,212 hunters polled opinion on the necessity of antlerless deer hunting and the factors that determine the number of deer in an area. Data are shown for the years 1962 through 1970. Data include the following. In 1970, 56.7 percent of the respondents felt it unnecessary to shoot does and fawns. Since 1967 the number objecting to shooting does has increased slightly. More of the successful hunters indicated a need for antlerless harvest than did unsuccessful hunters. Most of those who felt such a need mentioned reduction of population, starvation, and habitat damage as their reasons. Most of those who felt the harvests were unnecessary gave "too few deer" as the reason. About two-thirds of the hunters mentioned habitat as the most important factor in determining deer numbers.

KEYWORDS: Big game, either-sex hunt, Michigan, preferences.

752. ________ G. C. Jamsen, and L. J. Hawn

1970. Some facts about Michigan hunters. Mich. Dep. Nat. Resour. Res. Dev. Rep. No. 197, 25 p., illus.

This paper is a collection of tables and graphs, with data drawn from several years of hunter mail surveys, license sales figures, and census data. Data generally cover the period 1920 to 1968. Age, sex, and residence information are given with the data which include: age distribution, number of deer hunters utilizing firearms and bow and arrow, hunting license sales, occupations, hunting frequency, and number of license types.

KEYWORDS: Michigan, license fee, big game, historical value, characteristics.

753. Rymon, Larry Maring

1969. A critical analysis of wildlife conservation in Oregon. Ph.D. diss., Oreg. State Univ., 441 p.

Time period covered is from prior to white settlement to the year 2010. The Oregon Indian conducted himself as a "prudent predator"; the only major control he extended over his environment was burning. White pioneers in the 1840's settled in the best agricultural areas, also the areas of prime game habitat, and had a severe impact on wildlife populations. Drainage, reclamation projects, drought, and excessive killing reduced wildlife populations. After 1893, wildlife management evolved through periods of protection, stocking, refuges, and systematic management. Although wildlife populations have been largely restored through systematic management and protective legislation, they are again decreasing in numbers due to competition with man for living space and resources. It appears that the burgeoning human population will eventually cause the annihilation of many wildlife species, an unpleasant but real prospect for Oregon's future. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Management, Oregon, historical value, conservation, legislation.

S

754. Sandfort, Wayne W.
1972. Definitions of wildlife. 52d Conf. West. Assoc. State Game Fish Comm. 30 p. (mimeo)

The paper includes definitions, by State, of the terms: wildlife, rare, unique, common, uncommon, abundant, overabundant, extinct, and endangered species. Also included is a listing of Federal and State agencies with wildlife management responsibilities.

KEYWORDS: Library, surveys, profession, dictionary.

755. Sargent, F. O., C. C. Boykin, O. C. Wallmo, and E. H. Cooper
1958. Land for hunters...a survey of hunting leases. Tex. Game Fish. 16(9): 22-23, 29, illus.

Personal interviews with 48 ranch and farm managers in Texas show that seasonal and pasture leases constituted 68 percent of all lease types and the cost per hunter for a season varied from $10 to $150 or from $5 to $25 per day. Income to the farmer varied from $45 to $3,750 or from 4 cents to $1.53 per acre of leased land. Farmer attitudes toward leases were divided into (1) a means of controlling hunter numbers, (2) an unimportant but welcome source of additional income, and (3) a potentially significant source of income. Offered are recommended provisions for written hunting leases.

KEYWORDS: Lease, economics, Texas.

756. Sauer, Richard
1960. Hunting pressure composition in New York. N.Y. State Conserv. 14(3): 16-17, illus.

Paper presents analysis of hunter composition in 1956 according to age group and place of residence. Fewer city than country boys hunt in the 14- to 21-year age group. City hunters outnumber country hunters by more than 9 percent in the 21- to 34-year brackets, although they fall behind again in the 34- to 54-year bracket.

KEYWORDS: Crowding, New York, characteristics.

757. Saults, Dan
1953. Not just what: why? 18th Conf. North Am. Wildl. Trans. 18: 624-630.

Paper advocates a better system of conservation education to successfully sell a code of ethics.

KEYWORDS: Education, public relations, philosophy.

758. Schaefer, Richard K., and Kenneth C. Nobe
1969. Economic evaluation of the land acquisition program of the Colorado Division of Game, Fish and Parks. Colo. State Univ. Dep. Econ. NRE-6, 57 p.

Based on survey responses from 3,230 sportsmen, it appears that land acquisition and development procedures of the Colorado Division of Game, Fish and Parks do not take into account the current desires of a growing

number of sportsmen and recreationists in the State. A behavioral, socio-economic approach to estimating desired demand is introduced. This approach is oriented toward the concept of consumer sovereignty. The relationship between desired demand and supply is explored through benefit-cost analysis. Any recreational lands that could be purchased in fee simple, leased, or obtained through easement should be considered. Land acquisitions and improvement plans, or similar methods to express alternatives, benefits, and costs, should be developed for each possible site. Plans indicating maximum benefits per unit of cost are most desirable. Such plans would rank priorities on a systematic and economic basis, would readily indicate the benefits to be gained or lost, would provide a means for improving the efficiency of allocating the land acquisition budget, and should help to improve the bargaining position of the Division in its competition for scarce public funds.

KEYWORDS: Economics, resource use, administration, Colorado.

759. Schaffer, W. C.
1945. Fitness examination for hunters. 10th Conf. North Am. Wildl. Trans. 10: 66-70.

Fitness examinations to avert hunting accidents are refuted because: (1) they cannot measure hunter's mental reaction under extraordinary field conditions, (2) scale of operation is too extensive (700,000 hunters yearly in Pennsylvania alone), and (3) there is no practical standard. A questionable comparison of motor vehicle license examinations supports the contention that examinations would not achieve desired results. "Until a practical standard is devised, the examination of hunters appears to be largely a waste of time, effort and money." After 9 years as a hearing referee of more than 600 hunting accidents, author concludes that "primary causes of hunting accidents are greed and carelessness" and continued safety programs are the only way of attacking the problem.

KEYWORDS: Education, safety, accident.

760. Scheffer, Paul M.
1959. Farming for waterfowl in the Pacific flyway. 24th Conf. North Am. Wildl. Trans. 24: 238-244.

"Farming for waterfowl" describes the development and management of tillable lands for waterfowl. Data from the Pacific Coast indicate that lands of marginal agricultural value can profitably be used for waterfowl. Total operational cost is $36 per acre, and waterfowl land leases range from $75 to $100 per acre annually. Many waterfowl farming projects on non-club lands have been made under the Conservation Reserve Program which includes Federal cost-sharing to reduce initial development cost and also provides that wildlife may be the only harvestable crop.

KEYWORDS: Waterfowl, landowner-private, economics, management.

761. Scheftel, Zane
1958. An economic evaluation of the sport fishery in Minnesota. 23d Conf. North Am. Wildl. Trans. 23: 262-268.

A two-part investigation of fishing expenditures of non-resident and resident anglers was accomplished by a mail survey and personal interviews. Annual total expenditure averaged $96.86 for non-resident and $83.93 for resident fishermen. Few nonresidents fished in Minnesota during the winter season, but they made 2,850,000 summer season trips. Minnesota residents made 9,200,000 trips during the 1956-57 season.

KEYWORDS: Fishing, economics, Minnesota, resident vs. nonresident.

762. Schermerhorn, Richard W., and William K. Starkey
1966. An economic feasibility study--shooting preserves in Maryland. Univ. Md. Agric. Exp. Stn. Misc. Publ. No. 584, 34 p., illus.

The 18 Maryland shooting preserves analyzed by questionnaire were not heavily capitalized; their average investment, excluding land, was about $4,100 in 1965. The average preserve grossed $5,484 in revenue annually but showed a net cash return of $544. Pheasants were most popular and profitable and quail and ducks the least profitable. Although not high in terms of non-farm standards, income from hunting preserves is substantial when compared with returns from other farm enterprises. To be self-sufficient, a preserve would have to handle a very high volume of birds.

KEYWORDS: Refuge, Maryland, economics, plant and shoot.

763. Schierbaum, Donald L., and Philip U. Alkon
1963. Characteristics of a sample of cottontail rabbit hunters in eastern New York. N.Y. Fish Game J. 10(2): 125-138, illus.

During a 5-year study in three counties, over 200 hunters provided information about 3,300 cottontail hunts. The average hunter made eight hunts annually, each lasting 3¼ hours, during which he and one companion saw four cottontails and shot two. This averaged 4 man-hours per rabbit bagged. Hunts with dogs were longer, and on an hourly basis the take was as high without dogs.

KEYWORDS: Harvest statistics, management, New York, small game.

764. ________ and Donald D. Foley
1955. Movement of waterfowl hunters in New York State. N.Y. Fish Game J. 2(2): 232-238, illus.

The movement of waterfowl hunters in pursuit of their sport was studied by means of hunter bag checks and leg band analyses. Data from both sources indicated that over 70 percent of the gunners were within 25 miles of home. Few hunters traveled from one zone to another to take advantage of the 2 separate opening days.

KEYWORDS: Waterfowl, New York, characteristics.

765. Schindler, Daniel John
1968. A study of the efficiency of the double sampling technique for measuring recreational use at the Crab Orchard National Wildlife Refuge. M.S. thesis, South. Ill. Univ., 76 p.

Eight developed recreation sites were double sampled by vehicle traffic counters and by on-the-spot counts. Formulas were developed during the calibration period for estimating use. Results show 249,963 visitor days per year, with use concentrated in swimming, picnicking, sightseeing, and shore fishing. Two of the sites had large errors (49 and 29 percent) due to bus use and faulty counters, respectively. Four sites had acceptable errors of less than 20 percent, and two sites had excellent results of less than 10-percent error. Recommendations are given for use of traffic counters. Sport hunting use is reportedly heavy but was not considered in study. (Bibliography, 20.)

KEYWORDS: Refuge, non-consumptive use, fishing, research methods, Illinois.

766. Schneider, R. Michael
1969. The zoo's changing role. Parks Rec. 4(9): 41-44, 95-96, illus.

Zoological gardens everywhere are likely to find themselves without stock in the next generation unless they accept their new role as animal sanctuaries. Zoo design should consider people as well as animals.

KEYWORDS: Urban wildlife, non-consumptive use, refuge.

767. Schoenfeld, Clarence A.
1957. Public relations aspects of wildlife management. J. Wildl. Manage. 21(1): 70-74.

An appeal is made for more public relations and human behavior considerations in wildlife management. The management of game requires public support. Trained men are often pawns of ill-advised sportsmen; and unless a clear, candid summary of management activities is provided, the public will harass managers. Seventeen references are cited in making his case, divided between public relations and wildlife management; and several examples and parallels are given.

KEYWORDS: Public relations.

768. Schoenfeld, Clay
1963. Let's cut out the numbers game nonsense. Am. For. 74(5): 10-13, 55-56, illus.

As outdoor recreation increasingly becomes a principal forest product, a major problem will be allocating lands for recreational experiences of varying qualities. Needed is a more comprehensive use of user fees, restriction of quantity and control of quality in certain areas, heavy investment in research and education, a reexamination of the present administrative framework, and a recognition of the present conservation crisis. Open space, scenery, and solitude have joined cellulose as prime products of our forests.

KEYWORDS: Conservation, resource use, administration.

769. Schofield, Raymond
1966. Where do you hunt? Mich. Conserv. 35(6): 8-9, illus.

A map shows average number of deer hunters per square mile by Michigan counties, 1963-65, and square miles cut over for pulpwood, 1961-65. Migration of hunters from southwest to northeast Michigan often takes them through low hunter concentration areas to high concentration areas. (Origin of data not given. No analysis.)

KEYWORDS: Crowding, Michigan, preferences.

770. Schorger, A. W.
1955. Public and private shooting preserves for game birds and small game mammals. 45th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 45: 103-109.

The establishment of public hunting grounds is the most successful step taken to provide hunting. Private shooting preserves have a distinct place in the economy since they provide shooting, relieve pressure on general hunting areas, and provide cover. Public and private shooting grounds, however, are only stopgaps for the growing army of hunters. The best hope lies in converting the farmer into a game manager.

KEYWORDS: Wisconsin, refuge, landowner-private.

771. Schubert, Ted
1967. Hunting, fishing, and license fees. Colo. Outdoors 16(4): 1-4.

The most important game and fish legislation to be presented in the Colorado State Legislature in 20 years was five bills introduced in the 1967 session that embodied the increases for game and fish licenses. Reprinted in their entirety are the arguments by Representative Ted Schubert before the final vote was taken. His speech is credited with convincing the majority. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Legislation, license fee, fishing.

772. Schunke, William H., and Irven O. Buss
1941. Trends in the kill of Wisconsin whitetail bucks, 1936-1940. J. Wildl. Manage. 5(3): 333-336, illus.

The hunter contention that whitetail bucks are decreasing in weight and antler size is substantiated. Incidental to the study, the authors found that hunters used 34 different calibers and more than three times that many makes of rifles and shotguns to shoot 215 buck deer.

KEYWORDS: Big game, Wisconsin, equipment.

773. Schwanz, Lee
1963. They chased politics out of conservation. Nat. Wildl. 1(5): 10-13, illus.

Article tells how Missourians removed politics from their game and fish department and gives some highlights of the 25 years following this.

KEYWORDS: Missouri, conservation, politics.

774. Scott, Robert F.
1951. Wildlife in the economy of Alaska natives. 16th Conf. North Am. Wildl. Trans. 16: 508-523.

The present and future relationships between Alaska natives and the wildlife resource involve important sociological, ethnic, and economic implications far beyond the scope of apparent legal or moral rights. The need for intelligent controls and management is shown by past events and is more serious than would appear from a superficial view. The questions of wildlife conservation in Alaska are (1) what legal restrictions must be enforced to adequately control hunting pressure? (2) how can enforcement and education change unsound practices? and (3) what management measures could bolster the wildlife supply generally and locally? Although the "new economy" still doesn't generate enough cash income to replace the use of wildlife for food and clothing, both native and white Alaskans cling to a mental concept of living off the land.

KEYWORDS: Alaska, conservation, resource use, economics, native claims.

775. Scott, Walter E.
1946. Possible increase in post-war hunting. J. Wildl. Manage. 10(1): 72-73.

A questionnaire survey of 322 servicemen stationed in the south and central Pacific and from the States of Michigan, Wisconsin, and Minnesota provides some data on the expected increase in postwar hunting. Percentages

are based upon the number who have hunted or plan to do so. Of those servicemen reporting, 58 percent had previously hunted deer; and of the remainder, 26 percent planned to begin hunting upon return. Another 16 percent stated they would never hunt deer. Of the prospective increase in deer hunters, 84 percent are from city areas unsuitable to deer hunting. Small game had been hunted at some time by 87 percent of the servicemen, 5 percent indicated a desire to begin hunting small game, and 8 percent did not wish to hunt small game.

KEYWORDS: Preferences, historical value, characteristics, military.

776. ________
1948a. Controlled hunting. Tex. Game Fish. 6(10): 4, 21.

In the western States, controlled hunting is now an important management method used especially to prevent overshooting of big game and overconcentration of hunters. In the rest of the country, controlled hunting is still in the experimental stage. Except for the southeastern States, the legal authority to limit hunter numbers is frequently lacking. Although projects such as this can be operated by States in cooperation with Federal agencies on their lands, using their trespass powers in issuing permits, enabling legislation would be desirable. Wildlife managers should investigate the possibilities of controlled hunting to solve special problem cases. The sportsmen and the general public often favor additional regulations which will improve the recreational enjoyment of orderly hunting and prevent overharvesting of wildlife resources.

KEYWORDS: Historical value, management.

777. ________
1948b. Methods of controlled public hunting in the United States and Canada. J. Wildl. Manage. 12(3): 236-240.

Article examines historic development in controlled hunting, starting in 1629 in New Netherlands. Controlled hunting is mainly experimental except in the western States where it is used to prevent overshooting and hunter crowding. Legal authority to limit hunter numbers is lacking except in the southeastern States.

KEYWORDS: Historical value, Canada, management, legislation.

778. Searcy, Margaret Zehmer
1954. Tuscaloosa County hunting. M.A. thesis, Univ. Ala., 129 p.

This is a sociological study rich in hypothesis and premises. Participant observations of hunters plus 22 formal interviews provide data on history of hunting, hunting culture and customs, folklore, the hunting class and caste systems and their interrelationships, and hunting clubs of Tuscaloosa County and nearby areas. With sportsmanship as the guiding principle, unwritten "laws" are more rigidly enforced, by social exclusion, than written laws. Descriptions are given on the characteristics of 15 game species as to their prestige among hunters, hunting methods used, etc. Hunting prestige is based on who is participating, scarcity of game, cost, necessary skill, and food value of game. Prestige symbols include deer antlers, turkey feet and beards, homemade turkey callers, bobcat hides, and dogs, varying according to hunter's class and caste. Hunting dog description for each species of game and care is presented. The role of and participation in hunting by Negroes, women, and children are described.

For example, in raccoon hunting, the Negro's role is more than servant but less than equal, but in deer hunting he is a paid servant. Wives cannot escape husbands' hunting activities, and acceptance often comes after a trial of painful experiences. Many customs are described, e.g., the first deer kill is bled and smeared on the young hunter's body and clothing. Four types of hunting clubs are described with detail on size, membership requirements, dues, facilities, and social events.

KEYWORDS: Alabama, tradition, folklore, small game, big game.

779. Sears, Paul B.
1951. Wildlife in today's economy: biological and ecological values. 16th Conf. North Am. Wildl. Trans. 16: 23-26.

Economics deals with the needs which men feel strongly enough to pay for. The ecologist sets priorities to help discriminate among those needs. There is visible money in wildlife, but are squirrels, insects, or coyotes necessary? Plants and animals inhabited the earth long before man. They established an order that we violate at our own peril. Those who discount the importance of conservation often lack biological training, although even conservationists find it difficult to obtain precise and convincing evidence that wildlife is an essential part of any balanced habitat.

KEYWORDS: Economics, conservation, benefits.

780. Sendak, Paul E.
1968. A consumer analysis of licensed hunters and fishermen in Massachusetts. M.S. thesis, Univ. Mass., 206 p.

Also see Sendak and Bond (1970).

KEYWORDS: Fishing, Massachusetts, refuge, characteristics, economics, preferences.

781. _________ and Robert S. Bond
1970. A consumer analysis of licensed hunters and fishermen in Massachusetts. Univ. Mass. Agric. Exp. Stn. Bull. No. 583, 43 p., illus.

Questionnaire by mail to 1,070 of the 226,590 hunters and fishermen in Massachusetts yielded a 64.3-percent response. Of the 593 nonrespondents, 23 were contacted and agreed to complete the questionnaire. No significant differences were found between nonrespondents and respondents. Socioeconomic findings include: (1) Massachusetts sportsmen are more highly educated than those of the national average with 29 percent of them having gone beyond high school as opposed to 20 percent of the entire country; (2) no significant difference exists in job distribution between Massachusetts and the Nation's sportsmen; (3) level of hunting and fishing is unrelated to income; (4) fishermen devote more time to fishing than hunters to hunting because the fishing season is longer and Sunday is a legal day for fishing but not for hunting. Sunday makes up at least half of the weekly leisure for 79 percent of the hunters; and (5) a rural background is more prevalent among people who both hunt and fish than those who either hunt or fish. Other findings include: (1) 36 percent of the hunters and 47 percent of the fishermen were introduced to the sport by their parents; (2) the intensity of participation in hunting and fishing is little affected by socioeconomic

and childhood participation factors; (3) 46 percent of the hunters are willing to pay an owner for access to land, but hardly any fishermen were willing to pay to fish. Also presented is an analysis of marketing opportunities for hunting and fishing. (Literature cited, 25. See Sendak (1968) for Master's thesis of original data.)

KEYWORDS: Fishing, Massachusetts, refuge, characteristics, economics, preferences.

782. Severe, Bill
1967. Are the achievements of your wildlife law enforcement recognized? 21st Conf. Southeast. Assoc. Game Fish Comm. Proc. 21: 577-580, illus.

To command due respect, the law enforcement officer must upgrade his education, training, and personal characteristics. The director and commissioners must recognize the officer's abilities and accomplishments. The officer's salary must qualify him as a professional man.

KEYWORDS: Enforcement, education.

783. Severinghaus, C. W.
1952. Determination of the location of hunting pressure and ratio of success of Central Adirondack deer hunters in relation to distance hunted from a road - 1952. N.Y. State Conserv. Dep. Job VII-A, P-R Proj. W-89-R-1, 11 p.

Data were gathered at three big-game checking stations from 1,669 successful hunters. Tables present data and size of hunting party, days hunted per hunter, distance hunted from road, animals shot, and hunter-days per buck shot. Data are separated into road-based hunters (those who started each day's hunt from a point accessible by car) and camp-based hunters (those who hunted from a camp at least 1 mile from the road). Results show that 420 road-based parties averaged 3.6 men per party, and they hunted an average of 3.8 days. Thirty-six camp-based parties averaged 4.4 men per party and 5.4 days hunting. In cumulative percents, 32 percent of the hunters hunted within 1 mile of a road, 52 percent within 2 miles, and 70 percent within 3 miles.

KEYWORDS: Big game, New York, characteristics, harvest statistics, crowding.

784. _________ and C. P. Brown
1956. Hunting accidents in relation to types of deer seasons. N.Y. Fish Game J. 3(1): 88-92.

Records of deer hunting accidents in New York during 1941-54 were studied in relation to man-days spent afield in buck-only areas, in doe-only areas, and in either-sex areas. The number of accidents per 100,000 man-days was 1.9 in areas where bucks only could be hunted, and 0.6 where either-sex hunting was permitted. No accidents occurred on areas where does only were hunted, but the number of man-days afield was low. Data collected during 3 years reveal that less than one-quarter of all deer hunting accidents were due to people having been mistaken for deer.

KEYWORDS: Big game, New York, accident, either-sex hunt.

785. Severson, Keith E., and F. Robert Gartner
1972. Problems in commercial hunting systems: South Dakota and Texas compared. J. Range Manage. 25(5): 342-345.

Charging a fee to use private lands is relatively new to South Dakota, but it began in Texas in the early 1920's and today it is impossible to hunt big game and many small game species without paying a land-use fee. Success or failure of a commercial hunting operation depends on State hunting regulations, proximity of public lands, hunter demand, the amount of game available, and attitudes of landowners and hunters. These factors are compared in their effects on fee hunting in South Dakota and Texas.

KEYWORDS: Big game, upland game birds, commercial hunting, South Dakota, Texas, user fee, landowner-private.

786. Sewell, W. R. D., and J. Rostron
1970. Recreational fishing evaluation: a pilot study in Victoria, British Columbia. Dep. Fish. For., Ottawa, Can., 133 p., illus.

To develop and test methodology for identifying factors which influence recreational choices, a sample of 100 participants from Victoria, Canada, in the 1968 King Fisherman Contest were given a written questionnaire and were interviewed. Results show that salt water sport fishing appeals to people from all sections of society. Thirty percent of the respondents were in the managerial, professional, and technical occupational classes, 17 percent were craftsmen, 40 percent were clerks, laborers, and service personnel, 12 percent were retired, and 1 percent were students. Most of the sample (86 percent) completed high school, while 14 percent attended university, and only 5 percent had advanced degrees. Annual family income was less than $5,000 for 13 percent, between $5,000 and $9,000 for 63 percent, between $9,000 and $12,000 for 14 percent, and over $12,000 for 10 percent. Sport fishermen spend more time on salt water sport fishing than on other outdoor recreation activities. Fresh water fishing was an activity for only 55 percent of the salt water fishermen studied. Only 24 percent of those who went sport fishing also hunted in 1968, implying that hunting and fresh water fishing do not provide satisfactory off-season substitutes. Economically, 60 percent had invested over $500 in 1968, and 37 percent had over $1,000 invested in fishing alone. A relatively weak correlation was found between family income and investment in fishing equipment. Fishing participation rates were influenced by number of hours available and family responsibilities, but not costs. Factors which influenced demand included enjoyment of outdoor esthetics, enjoyment in planning the trip, getting away from work, and pleasure boating.

KEYWORDS: Fishing, characteristics, economics, Canada, non-consumptive use, benefits.

787. Shafer, Elwood L., Jr., Paul H. Amidon, and C. W. Severinghaus
1972. A comparison of violators and nonviolators of New York's deer-hunting laws. J. Wildl. Manage. 36(3): 933-939, illus.

A 1967 survey of 1,140 New York hunters revealed several differences and similarities between respondents who were known to have violated deer-hunting laws and respondents who were not known to have done so. Law violators legally killed significantly more deer per year of hunting experience than did nonviolators. Although violators encountered law enforcement officers more often, and felt that there was justification for breaking game laws if it were done accidentally or for food, they did not feel justified in breaking the laws to obtain psychological benefits such as the challenge or excitement involved. Both groups of hunters had similar investment costs for equipment and similar attitudes about various

hunting regulations. Dissatisfaction with regulations centered mainly on laws that regulated the distribution of hunters and their behavior patterns rather than on laws that regulated the number of deer harvested.

KEYWORDS: Characteristics, preferences, law violation, New York.

788. Shaw, Stanley
1961. An outline of content for wildlife education and a study of wildlife knowledge of high school seniors of Louisiana. Ph.D. diss., La. State Univ., 137 p.

Of the 50 States, 38 reported using some type of wildlife conservation materials. These materials were examined and analyzed according to their topics. Ninety-four wildlife leaders were selected to appraise and propose an outline for elementary and secondary school wildlife education. The appraisal group felt that details in wildlife education should not be emphasized and that greater stress should be placed on broad concepts of wildlife conservation. A test, consisting of 100 items, was administered to 3,266 seniors in 70 State high schools. Boys had a greater knowledge of wildlife conservation than girls, but even their knowledge was insufficient. Subjects considered helpful in taking the test were biology, general science, and fishing. The activity considered the least helpful was going to summer camp. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Education, Louisiana, surveys, conservation.

789. Shay, Ron E.
1964. A comparison of information retention by television and nontelevision hunter safety students in Oregon. 44th Conf. West. Assoc. State Game Fish Comm. Proc. 44: 324-327.

There is little difference between retention of material on television- and non-television-instructed hunter safety students over a 9-month lapse of time, and both television and non-television students retain virtually all of the information from the course when tested by written examination.

KEYWORDS: Safety, communications, education, Oregon.

790. Shea, John P.
1948. A new approach to farmer-sportsmen cooperation. 13th Conf. North Am. Wildl. Trans. 13: 163-169.

Human relation problems between farmers and sportsmen are a major wildlife management problem. In addition to physical and biological factors for wildlife studies, a social science survey is needed to determine human opinions, values, and institutions. To gain community cooperation, two types of group leaders should be located: (1) leaders of opinion (prominent people with reputation) and (2) action leaders (natural leaders without title; actions rather than words govern their lives). Failure to find, cultivate, and gain cooperation of action leaders has led to poor farmer-sportsman cooperation.

KEYWORDS: Public relations, farmer-sportsman relations.

791. Shepard, Paul, Jr.
1959. A theory of the value of hunting. 24th Conf. North Am. Wildl. Trans. 24: 504-512.

Hunting (killing) for sport is regarded as morally indefensible.

Historically, hunting has been defended as: (1) a sporting activity that prepares man for better conduct in human affairs, (2) the stalk that promotes character, self-reliance, initiative, (3) satisfaction for instinctive needs and psychological releases, (4) an excuse to escape civilization, and (5) affirming one's virility. None of these is valid, according to Shepard. Hunting confirms man's continuity with the dynamic life of animal populations, his role in the complicated cycles of elements and the sweep of evolution. "Killing and eating the prey are the most important things that hunters do." Early societies viewed hunting as ceremonial, highly ritualized, and an act of religion. As a contemporary ritual, hunting is based on a peculiar assemblage of restraints--legal, ethical, and physical--constituting sportsmanship. Restraints are balanced by man's technological advantage. (A philosophical article with rich insights. However, author dogmatically dismisses five theories of the value of hunting and replaces them with one of his own. References, 9.)

KEYWORDS: Philosophy, antihunting.

792. Shepard, Ward
1921. Science versus tradition in game protection. J. For. 19(4): 409-411.

Game protection in America revolves around bag limits, universal open or closed seasons, and unlimited license sales. These traditional principles have influenced game legislation, but they have failed to meet the needs of 20th century America. New Mexico's method of game protection includes a game commission empowered to establish game refuges and local closed season. Recent legislation provides an opportunity for cooperation between State and Federal officials, but the responsibility for game management is thrown to the State where vast amounts of public sentiment favor game management.

KEYWORDS: Administration, New Mexico, legislation, Federal-State jurisdiction.

793. Sherwood, Glen A.
1970. Characteristics of North Dakota goose hunters. N.Dak. Outdoors 33(3): 8-11, illus.

In personal interviews with 100 hunters, the average hunter had 24 years of general hunting experience and 15 years of goose hunting. Each fired an average of 68 shots at geese in eight hunts during each season. Hunting styles showed that 39 percent used decoys and hunted from a pit or blind; 30 percent used the crawl-and-sneak approach; 17 percent hunted from fence-lines; 9 percent preferred pass shooting; and 5 percent hunted in fields without decoys. The average hunter spent about $75 per year hunting geese, with transportation the single most expensive item. Reasons for goose hunting in order of importance are outdoor enjoyment, the challenge, and meat. Sixty-one percent of the hunters favored a seasonal limit of less than 16 geese; and although 11 percent of the hunters had paid a fee or leased land, 86 percent were opposed to the practice. On the average, hunters believed that 38 percent of their fellow hunters were poor sportsmen, favored increased restrictions, and supported increased duck stamp fees.

KEYWORDS: Characteristics, North Dakota, waterfowl, economics, preferences.

794. Shoemaker, Carl D.
1952. Status of new and pending legislation. 42d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 42: 123-131.

Paper is mainly a discussion of waterfowl management. It briefly covers the legislative status of the Tackett Bill which seeks to earmark 10 percent of the U.S. Forest Service receipts for recreation and improvement of wildlife habitat, the Lantoff Bill which calls for a refuge for the protection of Florida's Key deer, the Water Pollution Control Act, and the Johnson Bill which prohibits the construction of dams within National Parks and Monuments.

KEYWORDS: Waterfowl, refuge, economics, legislation, management.

795. ________
1954. A proposal for action on a wildlife legislative program. 44th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 44: 80-85.

Paper discusses four bills being introduced to Congress which would accelerate and advance the wildlife movement. These are the Pittman-Robertson Surplus Fund, the Baker Bill, the Duck Stamp Money and Refuge Program, and the Coordination Act.

KEYWORDS: Legislation, historical value, refuge, waterfowl.

796. Shooting Sports Association
1968. You and your lawmaker: a citizenship manual for sportsmen. 22 p., illus. Riverside, Conn.: Shooting Sports Assoc., Inc.

Booklet was designed to stimulate interest in legislation affecting outdoor recreation and to serve as a practical guide to intelligent and positive action by the sportsman.

KEYWORDS: Legislation, education.

797. Short, Alexander Walker
1939. Improvement in farmer-hunter relations in Ohio. 4th Conf. North Am. Wildl. Trans. 4: 514-518.

To alleviate access, enforcement, and hunter congestion, the Bureau of Game Management was created in Ohio. A game management agent system was adopted. Opening of public lands to State supervised hunting has reduced hunting pressure on private lands. Issuance of a license tab to be worn on the back has discouraged law violations. The use of permit tags issued on supervised areas trains hunters to ask permission to hunt, and the activities of both youth and sportsman's groups have been encouraged.

KEYWORDS: Management, Ohio, farmer-sportsman relations.

798. Sigler, William F.
1946. An experimental farmer-sportsman cooperative in Iowa. J. Wildl. Manage. 10(3): 274-275.

In 1940 two farmer-sportsman cooperative areas, initiated and administered by sportsmen, were received with mixed feeling by many other sportsmen. The organization easily obtained enough cooperating farmers in each area to serve as a testing ground for future work. Farm youths participated actively in the program.

KEYWORDS: Iowa, farmer-sportsman relations.

799. ________
1956. Wildlife law enforcement. 318 p., illus. Dubuque, Iowa: Wm. C. Brown Co.

The book includes chapters on: the need for adequate wildlife laws and for effective enforcement through an historical review of wildlife management and present day practices; the legal basis for various State and Federal game laws; the problems of State versus Federal ownership and jurisdiction over the Nation's wildlife resources, and the rights of private citizens; problems of wildlife law violation by minors, adults, and members of certain American Indian groups; officer's qualifications and professional preparation; departmental procedures; use of code books and indexes; legal and technical problems involved in making an arrest; the reserve-warden system; the officer in court; and the preparation of evidence. (Appendix includes 55 pages of definitions and legal terms; 265 references are given.)

KEYWORDS: Enforcement, law violation, legislation.

800. Simpson, James C., and Ted C. Bjornn
1965. Methods used to estimate salmon and steelhead harvests in Idaho. 45th Conf. West. Assoc. State Game Fish Comm. Proc. 45: 217-226, illus.

During 1964, estimates of steelhead trout harvest were obtained from a postal-card questionnaire survey, voluntarily returned steelhead permits, a random sample of steelhead permits, and check stations. Substantial bias was found. The random sample catch estimate was about one-half the size of the estimates based on the questionnaires and the voluntarily returned permits. Estimated catch from the South Fork of the Salmon River based on the random sample of permits was very close to the actual harvest of fish, as determined by check station count of virtually all the fish taken from the drainage. Relatively precise, accurate estimates of catch can apparently be obtained by the use of similar permits and a random sampling procedure.

KEYWORDS: Research methods, fishing, harvest statistics, Idaho.

801. Singh, Ajmer
1965. An economic evaluation of the salmon-steelhead sport fishery in Oregon. Ph.D. diss., Oreg. State Univ., 176 p.

Estimates have been made of annual expenditures by salmon-steelhead sport anglers, the net economic value of this resource, and some basic relationships of fishermen's demand for salmon-steelhead fishing. Data were obtained from 4,400 returned questionnaires and 305 personal interviews. Net economic value was estimated by simulating a market pricing mechanism. During 1962, these anglers spent over $9 million for durable fishing equipment and over $8 million on "current" expense items associated with fishing trips. With license expenditures counted, the annual gross economic value of the sport fishery was about $18 million, plus or minus $3 million. Net economic value (if a market existed for the opportunity of fishing for salmon-steelhead) was estimated at $2.4 to $3.0 million per year. A 40-percent increase in net economic value to $4 million annually within 10 years is possible if income and population trends of the past 15 years continue. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Fishing, economics, Oregon.

802. Sloan, E. F.
1954. Hunter safety through education. 34th Conf. West. Assoc. State Game Fish Comm. Proc. 34: 319-324.

A summary is given of events leading up to the development of the National Rifle Association's Hunter Safety Training Course and a discussion of the California Hunter Safety Training Program.

KEYWORDS: Safety, education, California, historical value.

803. ________
1964. The National Rifle Association and firearms legislation. 44th Conf. West. Assoc. State Game Fish Comm. Proc. 44: 110-113.

The article presents a statement of policy concerning firearms control legislation and a review of the status of several Federal bills. The ownership of firearms must not be denied to American citizens of good repute if they use them for lawful purposes.

KEYWORDS: Legislation, safety, equipment.

804. Smith, Anthony Wayne
1962. The National Parks Association position on hunting in the Parks. 52d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 52: 20-23.

Paper suggests continuation of the no-hunting Park policy.

KEYWORDS: Non-consumptive use, resource use, antihunting.

805. Smith, Charles F.
1949. For better conservation: realistic game management. Wis. Conserv. Bull. 14(1): 3-5.

"Real" game management rejects "aspirin" cures and emphasizes fishing and hunting on a sporting rather than a meat basis.

KEYWORDS: Conservation, management.

806. Smith, Gene
1969. Hunting...fair or foul? Fla. Wildl. 22(9): 19-21, illus.

Opposition by preservationists to lawful hunting is increasing in Florida, but conservation's wise-use concept calls for a regulated harvest of some wild species. Also sportsmen's donations pay for wildlife research and management, whereas the preservationists pay few of the country's mounting wildlife conservation bills. Hunters and preservationists should cooperate to perpetuate wildlife populations with variety and numbers for everyone to see, enjoy, and harvest.

KEYWORDS: Conservation, Florida, antihunting.

807. Smith, Herbert A.
1915. Hunting on the National Forests. Am. For. 21(3): 172-182, illus.

Author argues that the natural balance of nature must be replaced by an artificial balance, such that the greatest satisfaction of human requirements is realized. This includes killing predators to decrease livestock losses and checking the natural increase of elk and deer by hunting.

KEYWORDS: Management, historical value, predator, resource use.

808. Smith, J. R.
1960. We can produce more game. Wis. Conserv. Bull. 25(3): 3-5, illus.

Landowners must have economic incentives to make game an attractive crop and to permit hunting.

KEYWORDS: Farmer-sportsman relations.

809. Smith, J. R., and H. C. Jordahl
1959. Two decades of progress on Wisconsin's public hunting and fishing grounds program. 24th Conf. North Am. Wildl. Trans. 24: 322-344.

Wisconsin's 20-year program of lease and purchase of land has resulted in opening 5,133,778 acres for hunting and fishing. Data from the 20-year period are summarized and several generalizations are drawn. Sound programs of land leasing and purchase must be provided by continuous earmarked funds. Private initiative should develop fee shooting. Steps are being taken to use zoning power to preserve wetland, but where conflicts with other economic interests occur, cooperative programs are developed.

KEYWORDS: Wisconsin, characteristics, upland game birds, economics, lease, landowner-public, historical value.

810. Smith, R. H.
1961. Results of pilot work on a small game hunter take survey. 41st Conf. West. Assoc. State Game Fish Comm. Proc. 41: 168-171.

A pilot study during the 1960-61 hunting season evaluated various phases of a small game questionnaire. In one survey, 500 hunters were contacted preseasonally by tally cards available through specified license dealers and then sent a post-hunting-season questionnaire. Another group of 500 hunters was not contacted preseasonally, but they received a post-hunting-season questionnaire. After one followup, 84.4 percent of the preseason group and 74.4 of the post-season-only group had responded to the questionnaire. The preseason group were more successful and had a higher percentage of participation.

KEYWORDS: Research methods, small game, upland game birds.

811. Smith, R. J.
1960. Wildlife and recreation--its place on public lands today. 50th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 50: 90-93.

Not all Federally administered lands (which total approximately a third of the continental United States) are meeting the increasing demand for recreation and wildlife. Forest Service lands best meet the basic requirements of water, timber, mountains, and space for privacy and freedom to move around. The Bureau of Land Management cannot meet future challenges unless Bureau lands are made permanent public lands, more realistic fees are charged for land use, and multiple use management is provided. The National Park Service should initiate controlled big game harvest programs in cooperation with State fish and game departments. Hunting should be encouraged on National Refuge and Department of Defense lands whenever the sport would not interfere with the primary purpose of these lands.

KEYWORDS: Landowner-public, non-consumptive use, resource use, administration

812. Smith, Robert J., and N. J. Kavanagh
1969. The measurement of benefits of trout fishing: preliminary results of a study at Grafham Water, Great Ouse Water Authority, Huntingdonshire. J. Leisure Res. 1(4): 316-332.

Recreation benefits were measured by a Clawson-type demand curve for a trout fishery, the basis of which is a relationship between distance and visitation rates from zones surrounding the fishery. Nearly 23,000 permittees caught over 32,000 fish. Recreational demand for trout fishing was measured, and data indicate that gross annual recreation economic benefits in 1967 were approximately 45,632 British pounds.

KEYWORDS: Fishing, economics, benefits, England, research methods.

813. Smith, Tommy L.

1959. A study of conservation information flow in western Montana. M.S. thesis, Mont. State Univ., 67 p.

The study attempted to determine the effectiveness of the following information and education techniques used by the State Fish and Game Department: a Wildlife Forum series, to discover changes in wildlife comprehension of those attending; radio-TV and other news media in western Montana to determine their use of department news releases; a circulation count of the department publication, "Montana Wildlife"; and public exhibits, displays, and contacts by department field personnel. Data were gathered through a written questionnaire, along with newspaper releases, subscription files of the department publication, and records of personal contacts made during the 3-week sample period by department personnel. Results of the study show that there was no radio or TV coverage, but utilization of these would probably improve the department's program; more locally-oriented fish and game news releases would increase their use in smaller newspapers; and the "Montana Wildlife" publication is mailed to 741 people in the study area. Department personnel averaged 11 public contacts per employee per day for the 21-day sample period, indicating the importance of this type of public relations.

KEYWORDS: Montana, education, communications.

814. Snapp, Charles C.

1956. A commissioner's viewpoint on law enforcement. 10th Conf. Southeast. Assoc. Game Fish Comm. Proc. 10: 180-181.

Paper discusses qualifications and training of Arkansas' conservation officers.

KEYWORDS: Enforcement, education, Arkansas.

815. Snyder, Bill

1952. Better than medicine. Fla. Wildl. 6(3): 14, 15-47, illus.

A game commissioner and VA hospital sponsor a therapeutic fishing program for disabled patients. An outing and personal reactions are described.

KEYWORDS: Fishing, benefits.

816. Snyder, Harold Z.

1961. An investigation of the educational potential of the Kellogg Bird Sanctuary. Ph.D. diss., Mich. State Univ., 192 p.

Appreciation of wildlife on the Michigan State University's Kellogg Bird Sanctuary was significantly improved for groups of fourth-grade classes receiving pretrip training and preparation. Minimal appreciation was expressed by those without the preparation. The author developed educational classroom instruction units on waterfowl, trees, mammals, and conservation practices. Recommendations are made to utilize a specific program in the sanctuary's education program. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Refuge, education.

817. Snyder, Jonas Louis

1964. Progress of shooting preserves in Michigan. M.S. thesis, Univ. Mich., 79 p.

Restricted to University of Michigan campus use.

KEYWORDS: Refuge, Michigan, historical value.

818. Sofranko, Andrew J., and Michael F. Nolan
1970. Selected characteristics, participation patterns, and attitudes of hunters and fishermen in Pennsylvania. Pa. State Agric. Exp. Stn. Bull. 770, 39 p., illus.

A random sample consisted of 318 hunters, 116 fishermen, and 338 persons with both licenses. The majority of all three groups were male, married, and employed. Almost a fifth of the hunters were students, and a fourth of the fishermen were either retired or housewives. Of all the sportsmen, half had some high school education, a fifth had none, and one out of 10 had completed college. Most of the sportsmen were in the middle income group. About seven out of 10 sportsmen with hunting licenses and one-half of the fishermen had spent their youth in rural areas. Factors determining hunting and fishing participation were age, number of hours worked daily, whether sportsmen had a paid vacation, the number of days off each week, and frequency of hunting participation during youth. Sportsmen took children and wives fishing more often than hunting. Hunters had more access problems than fishermen. Most sportsmen wished to preserve the landowner's right to post but were unwilling to pay for use of the property. When compared with urbanites, hunters and fishermen differed in participation in only one of seven activities--picnicking.

KEYWORDS: Fishing, Pennsylvania, characteristics, preferences.

819. _________ and Michael F. Nolan
1972. Early life experiences and adult sport participation. J. Leisure Res. 4(1): 6-18, illus.

Mail questionnaires were sent to 1,000 hunters and fishermen in Pennsylvania during 1965. Response rate was 77 percent (318 hunters, 116 fishermen, and 338 combination hunters and fishermen). Results show that youth participation was directly related to adult participation, even when residence and "how sportsman was introduced to sport" were held constant. Frequent youth participation was associated with high levels of adult participation. Rural area youths and those introduced by their parents tended to participate more in hunting or fishing as a youth than those from non-rural areas or those introduced by another source. Variables important to youth participation may recede in adult life when other factors take precedence such as work condition, income, free time, and access.

KEYWORDS: Pennsylvania, fishing, preferences, characteristics.

820. Sohn, Arnold Joseph
1968. Competitive recreational uses of selected Iowa lakes. M.S. thesis, Iowa State Univ., 171 p., illus.

The activity on five Iowa lakes, user conflicts, and reasons for use fluctuation were determined by time-lapse cameras, mail back questionnaires sent to lake users and to lake residents, pneumatic car counters, and line-intercept boat counts. Fishermen reported fishing most often during early morning hours from 5 a.m. to 8 a.m., but evaluation of time-lapse pictures showed greatest activity from 9 a.m. to 11 a.m. Saturday and Sunday comprised 46 percent of the total fishing pressure. Residents generally thought that pleasure boaters and fishermen did not conflict with one another, but 75 percent favored the zoning of areas for these specific uses. A majority of interviewees agreed with the statement "we tend to select vacation lakes on the basis of their fishing quality."

Fishing ranked high among five other activities as being the "most enjoyed" at three lakes. Fishing and other activities are compared for age and occupation. Hunters indicated that hunter concentration was favorable although high. Hunting parties averaged more than 2.5 persons, and their average age was about 31 years. (Recommendations are given, along with 21 reference citations, interview schedule, and questionnaire.)

KEYWORDS: Iowa, fishing, waterfowl, crowding, preferences, characteristics.

821. Solman, Victor E. F.
1951. The creel census in the national parks of Canada. 16th Conf. North Am. Wildl. Trans. 16: 225-233.

The history of recording fish catch by creel census is summarized, with emphasis on Canadian programs. Several factors important to lack of angler cooperation are: misunderstanding of the aims of the creel census, mistrust of government activities, reluctance to admit failure to take a bag limit, and reluctance to admit breaches of angling regulations.

KEYWORDS: Fishing, harvest statistics, Canada, historical value.

822. Sorrells, Cliff
1957. Should sidearms be worn by game and fish enforcement personnel? If so, how and when? 37th Conf. West. Assoc. State Game Fish Comm. Proc. 37: 305-307.

A game and fish enforcement officer, who has the required qualifications for the position, should be authorized to wear a sidearm at any time and any place while performing his duties.

KEYWORDS: Enforcement.

823. __________
1958. How can the States more adequately enforce the license provisions of nonqualified holders of resident licenses? 38th Conf. West. Assoc. State Game Fish Comm. Proc. 38: 313-314.

Paper is primarily a discussion on Arizona's solution. Lists suggestions for enforcing license provisions: publicity, training of license sellers, investigations, stiffer license requirements, efficiency, and cooperation between States.

KEYWORDS: Enforcement, Arizona.

824. Spaulding, Irving A.
1970a. Selected Rhode Island sport fishermen and their fishing activity. Univ. R.I. Agric. Exp. Stn. Bull. No. 403, 31 p.

Data were collected by questionnaire during 1968 from boat-using sport fishermen. The report is presented in three units: social characteristics of the fishermen; their fishing activity; and the values they experience in their fishing activity. Most fishermen were between 40 and 59 years old, male, and married with two to four children at home. Most had finished high school. Income ranged from under \$4,000 annually to \$20,000 or more. More prevalent were those incomes between \$8,000 and \$12,000. Boats used were characteristically power boats, between 15-19 feet in length, made of wood, and with 30-60 horsepower motors. Daytime fishing was preferred to night fishing, and fishing at high tide was preferred. Occupational associates were indicated as fishing companions less frequently than family

members and others. Values associated with fishing ranked from greatest to least are: euphoric-tension dynamic, catching fish in the fishing situation, person-environment relationship, other relationships in the fishing situation, and lastly, situation change.

KEYWORDS: Fishing, Rhode Island, characteristics, preferences.

825. ________
1970b. Variation of emotional states and environmental involvement during occupational activity and sport fishing. Univ. R.I. Agric. Exp. Stn. Bull. No. 402, 78 p.

On the whole, tension levels were lower during sport fishing than during occupational activity. Occupational categories--professionals, managers, craftsmen, and all others--did not differ with respect to the influence of mechanistic devices on occupational activity, even though they did differ with respect to the influences of other people, one's own feelings, and natural events. The occupational categories did not tend to differ widely with respect to regulatory influences on sport fishing. Mechanistic devices and other people tended to influence occupational activity more than one's own feeling and natural events; for sport fishing, the influence of these pairs was reversed. In the value orientation of the fishermen, emphasis was found most frequently on experiencing some degree of change in euphoria-tension level; emphasis was placed least frequently on personal integrative responses such as "being oneself," "thinking things through," or "forgetting." Frequently mentioned were catching fish, experiencing the environment, the people with whom one went fishing, and the esthetic characteristics of the setting in which one fished.

KEYWORDS: Fishing, Rhode Island, characteristics, preferences.

826. ________
1971. Occupation, recreation and phasic commutation: selected Rhode Island sport fishermen. Univ. R.I. Agric. Exp. Stn. Bull. 405, 43 p.

Study involves a mail questionnaire to 302 fishermen. Analysis is based upon 146 respondents. A euphoria-tension index measured states of relaxation and states of tension, while an energy-fatigue index measured states of being tired and states of being energetic. These indexes were compared on fisherman occupational categories. Fluctuation between the two states resulting from moving between occupation and sport fishing is termed phasic commutation. A portion of the data supports evidence for a principle of phasic commutation while other data do not. There was evidence that the two indexes are functionally independent.

KEYWORDS: Characteristics, Rhode Island, fishing, benefits.

827. Spillman, Robert J.
1961. What the sportsman expects from the land. 41st Conf. West. Assoc. State Game Fish Comm. Proc. 41: 27-30.

The understanding sportsman expects access to private and public land, wise conservation and management practices, and good hunting and fishing at a reasonable price. The unreasonable sportsman is merely concerned with good hunting and fishing. He is disdainful of multiple land use, property rights, or volunteering his time to conservation. A sportsman, however, should expect to reap only what he sows in time and effort.

KEYWORDS: Farmer-sportsman relations, landowner-private, landowner-public.

828. Stack, Robert
1971. Thanks to the hunter! Nat. Wildl. 9(6): 17.

In this "Age of Environment" many preservationists oppose hunting in the name of conservation. However, hunting, game management, conservation, and environmental concern are partners. Sportsmen, at least, put their money where their mouths are. By buying licenses they provide money for fish and game programs and pay the salaries of fish and game department people.

KEYWORDS: Conservation, antihunting.

829. Stains, Howard James
1951. An economic survey of North Carolina's wildlife resource. M.S. thesis, N.C. State Coll., 140 p., illus.

Mail questionnaire surveys, with interview followups of nonrespondents, were conducted on five categories of hunters and fishermen, game breeders, veterinarians, kennel owners, equipment jobbers, sportsman's magazine publishers, and five miscellaneous wildlife values. Returns ranged from 20 to 70 percent. Expenditures generated by wildlife exceeded $46 million for the State. Fishing accounted for $22 million and hunting, for $15.5 million. Sportsmen showed preference for rabbit, squirrel, quail, bass, panfish, catfish, and trout. Expenditure by items, pounds of game caught, and kill data are listed in detail. (References, 37.)

KEYWORDS: Fishing, preferences, economics, harvest statistics, North Carolina.

830. Stamm, Keith R.
1970. Two orientations to the conservation concept of scarcity. J. Environ. Educ. 1(4): 134-139.

A stratified, random sample of 607 Wisconsinites was interviewed to determine the conflicting interpretations of the term "conservation" and the origins of the interpretation. Scarcity is the crux of conservation disputes, and two views predominate: (1) harvesting to reverse trend toward scarcity of browse, and (2) feeding of functional equivalents for browse. Scarcity orientation was measured by questions which dealt with conservation problems. Results indicate that Wisconsin's hunters, fishermen, campers, and hikers are more likely than nonparticipants to hold either the functional equivalents or reversal of trends orientation to scarcity. The hypothesis that participants in outdoor activities would be more reversal-oriented was strangely not supported, as this group was associated with both orientations. Hunters, fishermen, campers, and hikers were more likely than nonparticipants to read outdoor conservation columns and magazines and to belong to conservation groups. Results show that readers of conservation columns and conservation group members significantly scored high on reversal more often than nonreaders. Readers of conservation magazines scored higher than nonreaders on both reversal and functional equivalents. Study results indicate that the conservation media do not play a very strong role in shaping an individual's scarcity orientation. (A pioneering study in an important area of environmental attitudes and the media responsible for those attitudes.)

KEYWORDS: Conservation, Wisconsin, characteristics, education, communications.

831. Stanojevic, Tihomir
1967. Where is the limit between the right of man to the game and the right of game to exist. 7th Congr. Int. Union Game Biol. Trans. 7: 503-508.

Today's man must not deprive future generations of the precious, natural wealth of game. The right of game to exist is determined by the obligation owed to future generations to insure their right of observing wild game. Cooperation between countries is necessary to insure an adequate supply of game.

KEYWORDS: Non-consumptive use, conservation.

832. Stealey, Wallace Rozell
1968. The politics of the Colorado Department of the Game, Fish, and Parks. Ph.D. diss., Univ. Colo., 182 p.

Author examines the State agency bureaucracy, centering upon the interaction and alliance structure developed by the Colorado Department of Game, Fish and Parks for purposes of achieving policy freedom. The existence of a subsociety incorporating both "in" and "out" groups was documented with situational data according to each group's respective role. Group pressures and governmental political significance were tied to game, fish, and parks politics in Colorado. A more direct association between the governor and the department was suggested. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Colorado, administration, politics.

833. Stearns, Forest W.
1967. Wildlife habitat in urban and suburban environments. 32d Conf. North Am. Wildl. Nat. Resour. Trans. 32: 61-69.

Paper points out the potentials and problems of urban wildlife habitat. Such habitats provide the last major opportunity for city dwellers to contact the realities of nature. Urban wildlife provides a laboratory for the public schools to teach ecological concepts such as carrying capacity and territoriality.

KEYWORDS: Non-consumptive use, education, urban wildlife, benefits.

834. Stevens, Joe B.
1966. Angler success as a quality determinant of sport fishery recreational values. Am. Fish. Soc. Trans. 95(4): 357-362.

Three Oregon sport fisheries--salmon, clam, and bottom fish--were economically evaluated to determine benefits that would result from several pollution control alternatives. A multiple regression analysis of angler responses to a mail and field questionnaire showed that a hypothetical 10-percent increase in probability of success in salmon angling would induce a 3- to 6-percent increase in effort. Bottom fish anglers did not exhibit this degree of responsiveness to success. Increased income and travel distance were reflected in more pronounced responses to success changes. If pollution reduced angler success by 50 percent, the yearly net economic value of the aggregate sport fishery would drop from $22,747 to $12,375.

KEYWORDS: Economics, Oregon, fishing, preferences.

835. ________
1969. Measurement of economic values in sport fishing: an economist's views on validity, usefulness, and propriety. Am. Fish Soc. Trans. 98(2): 352-357.

Disagreement over measurement of recreation values stems from poor communication between the biologist and economist. Validity, usefulness, and propriety are explained in the context of economic valuation of recreation resources. To whom values accrue cannot be separated from recreational "value." Values accrue to anglers and to the economy of an area in the form of income flows. Controversy arises over placing empirical estimates on these two types of values and the role they play in public decisionmaking. One should neither blindly accept nor reject recreation demand estimates, because the following considerations will determine the utility of the estimate: possible exclusion of certain users such as non-consumptive users, exclusion of "option demand" by nonusers (people who do not use the resource even as a spectator but who place a value on its existence or may want the option of use in the future), and the possibility that a decision will lead to future unwanted and irreversible consequences.

KEYWORDS: Economics, resource use, fishing, non-consumptive use, management.

836. Stiles, Bruce F.
1951. Keeping land open to public hunting. 41st Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 41: 122-126.

Paper gives rambling discussion on how hunters in Iowa individually gain access to farms through preseason contracts with farmers.

KEYWORDS: Farmer-sportsman relations, Iowa, access.

837. Stoddard, Charles H.
1951. Wildlife economics--a neglected tool of management. 16th Conf. North Am. Wildl. Trans. 16: 17-22.

Freedom of the outdoors is not strictly biological but social and economic as well. The ecological motive need not be in direct competition with the profit motive.

KEYWORDS: Economics, landowner-private, resource use.

838. ________ and Albert M. Day
1969. Private lands for public recreation: is there a solution? 34th Conf. North Am. Wildl. Nat. Resour. Trans. 34: 186-196.

Recreational activities are usually pursued by individuals or very small groups and require little more than access to land, water, and wildlife. Impediments to public access include a lack of economic incentive, blocking of public land by private holdings, and the American "pioneer" attitude of free access. Past and current efforts to resolve the problem center mainly around landowner permission or sportsman education programs and the increasing use of private company lands. The American Forest Institute claims 93 percent of the industry lands are available to the public for recreation. Any successful access plan should provide for request by the user, liability relief of owner, responsibility of user for damage, revenue to the landowner, creation of a manageable unit, and a public information program.

KEYWORDS: Non-consumptive use, landowner-private, access.

839. Stokes, Gerald Lamar
1966. Outdoor activity and personality. M.S. thesis, Univ. Ga., 56 p.

Bibliography, 18; questionnaire; dogmatism scale; and Gough-Sanford Rigidity Scale are included. For summary see Moss, Shackelford, and Stokes (1969).

KEYWORDS: Fishing, research methods, characteristics, benefits.

840. Strahle, Ronald
1964. The problems of access. 44th Conf. West. Assoc. State Game Fish Comm. Proc. 44: 114-116.

Public access to over $1\frac{1}{2}$ million acres of public lands in Colorado is blocked by 236 private landowners. Four approaches--force, persuasion, the profit motive, and education--are combined to solve the problem.

KEYWORDS: Access, landowner-private, resource use, Colorado.

841. Stransky, John J., and Lowell K. Halls
1968. Small forest holdings could be combined for hunting leases. 22d Conf. Southeast. Assoc. Game Fish Comm. Proc. 22: 125-127.

Small holdings characterize most forest land in the South. Much needed hunting land and income for rural landowners could be provided by combining small forest holdings into large units and leasing the hunting rights.

KEYWORDS: Landowner-private, lease.

842. Street, D. R.
1967. Recreation economics--fee fishing in Pennsylvania. Pa. State Univ. Dep. Agric. Rural Sociol. No. 62, 10 p.

Interviews held with 119 operators in 1962 to determine income from fee fishing lakes revealed the following: (1) small demand for fee fishing services; (2) excess of fee fishing lakes; (3) low profits and, to some operators, severe losses; (4) special circumstances necessary for successful fee fishing lakes. These circumstances have not been considered in analysis. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: User fee, Pennsylvania, fishing, landowner-private, economics.

843. Street, Donald R.
1969. The fee fishing lakes as a business in Pennsylvania. Pa. State Univ. Agric. Exp. Stn. Bull. No. 755, 24 p., illus.

Interview were made with 119 respondents out of a total of 125 commercial fishing lake enterprises. Only 89 firms had sufficient data to determine income levels. Of these, only 39 firms had a positive net return to family labor, management, and investment; 50 firms had a negative income. Half of the firms were, therefore, subsidizing recreation. Only 12 firms had sufficient residual income to pay their own labor $1 per hour. Of the 119 lake operators, 93 had some other occupation. The losses were as high as $4,500 per year while gains went up to $18,000. Data analysis indicated that it was not economically feasible to establish fee fishing lakes. Demand is low, and there is an excess of supply. Several means were available to improve the efficiency of operations, including fish culture education and improved business management practices. (Bibliography, 10.)

KEYWORDS: Economics, landowner-private, Pennsylvania, user fee, fishing.

844. Strohm, John
1966. Conservation hall of fame: John J. Audubon. Nat. Wildl. 4(2): 29.

A brief biographical sketch of Audubon, an ornithologist-artist who contributed to the foundation of the conservation movement.

KEYWORDS: Historical value, biography, conservation.

845. Stroud, Richard H.
1957. Financial aspects of fishing and hunting licenses. 47th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 47: 57-63.

Nationally, four basic fishing licenses and five basic resident hunting licenses collectively produce over 90 percent of the revenues. Yet there are about 70 different types of resident hunting licenses alone. Variety of licensing is essentially a fund-raising device which falls short of producing the needed revenue. Yearly, 25 million sportsmen spend $3 billion, but only 3 percent of this sum goes for license purchases. The average spent on licenses per angler or hunter in 1955 was $3.10. License types should be consolidated. Nationwide, substitution should be made of extra-fee resident licenses, carrying reciprocity privileges with other States, for the present array of non-resident and short-term licenses. Fees should be increased several-fold, and license coverage should be extended to all users of the resource.

KEYWORDS: Fishing, economics, license fee.

846. ________
1967. Environmental quality: costs versus benefits. Bull. Ecol. Soc. Am. 48(2): 47-49.

The cost of preserving our environmental quality will have to be measured against long-term benefits using economics as a criterion. This article presents an excellent example from the Galveston-Trinity-East Bay estuarine complex, where the recreation use for sport fishing outweighs the commercial use by 36 times the economic value as a source of limestone aggregate and calcium. (Condensed from "Index to Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Economics, resource use, fishing.

847. Sturges, Frederick W.
1959. Report on the Izaak Walton League of America's "Hunt America Time program." 49th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 49: 128-131.

Paper summarizes the objectives of the program and its accomplishments in various States including: relief of hunter pressure, better farmer-sportsman relations, reduction of hunting accidents, and representation of sportsman interests at the State level.

KEYWORDS: Farmer-sportsman relations, safety.

848. Surber, Eugene W.
1968. Effects of a 12-inch size limit on smallmouth bass populations and fishing pressure in the Shenandoah River, Virginia. 22d Conf. Southeast. Assoc. Game Fish Comm. Proc. 22: 300-311, illus.

Total fishing pressure for 1964 through 1967 of the Shenandoah River was determined by airplane censuses of fishermen. Creel checks supplied information on fish species caught and fisherman hours. Serious bass stock depletion occurred in 1964 and was remedied in 1965 by imposing a 12-inch minimum length size on bass. Total fishing pressure has decreased from 140,000 fishing hours in 1964 to 75,000 hours in 1967.

KEYWORDS: Harvest statistics, fishing, Virginia, management.

849. Swank, Wendell G.
1966. Solutions to some multiple use recreation problems. 46th Conf. West. Assoc. State Game Fish Comm. Proc. 46: 425-431.

Paper discusses the outdoor recreationist in general but mainly the problem of growing criticism of the hunter. Contention that hunting is hazardous to other recreationists is refuted. We need to organize to save hunting.

KEYWORDS: Resource use, public relations, antihunting.

850. Swanson, Evadene Burris
1940. The use and conservation of Minnesota game 1850-1900. Ph.D. diss., Univ. Minn., 321 p.

After the Indian treaties of 1851 opened Minnesota for farming, most of the State's wilderness aspects were obliterated and wildlife became adapted to settlement. Newspaper reports and fur company records reveal the extent of the fur harvest during this period. Market hunting, aided in 1870 by improved transportation and refrigeration, supplied game to restaurants, hotels, and lumber camps. In addition to the depredations of commercial hunting and trapping, wildlife was subjected to lumbering and land drainage activities. While several new game species appeared, others became scarce or moved their range. Restrictions on methods of hunting and trapping were formed, and market hunting was condemned even in 1871, but official provision for law enforcement was not made until 1890. When Federal law supported State statutes by prohibiting game shipments as part of interstate commerce in 1900, conservation had won its first great battle and opened the way for progress in the twentieth century. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Historical value, Minnesota, trapping, legislation.

851. Swanson, Gustav A., and E. L. Cheatum
1957. Public hunting--the problem, the program. N.Y. State Conserv. 11(11): 2-3, 33, illus.

Increasing amounts of land are being posted against hunting. A suggested Wildlife Management Practice Act would initiate wildlife management practices on privately owned lands, improve access to them, and provide safety zones and adequate control for the cooperating farmer.

KEYWORDS: Landowner-private, access, legislation.

852. _________ and Eugene C. Waldbauer
1967. Public hunting opportunities in the State of New York. 32d Conf. North Am. Wildl. Trans. 32: 89-95.

New York and other States with large populations still offer surprisingly great opportunities for public hunting. A statewide study indicates

that, of the less densely populated areas which comprise 84 percent of the State, only 26 percent are posted against hunting. Even on posted land, 50 percent said they would allow hunting if strangers would ask permission. Categories of lands and landowners are discussed in terms of the different needs and opportunities represented by each.

KEYWORDS: Landowner-private, New York, access.

853. Swift, Ernest
1961. Esthetic values and merchandising. Wyo. Wildl. August: 34-37, illus.

Wildlife's esthetic and cultural values are rapidly being lost to the mass greed of merchandising with the false attitude that if wildlife cannot be eaten or sold, it is not worth preserving.

KEYWORDS: Philosophy, esthetics, economics, benefits.

854. ________
1964. Private hunting. Fla. Wildl. 17(9): 5, 26.

Author discusses private shooting preserves as an infringement on public rights.

KEYWORDS: Landowner-private, refuge.

855. ________
1965. Conservation hall of fame: Aldo Leopold. Nat. Wildl. 3(3): 20.

Brief biographical sketch is given of Leopold as a conservation visionary.

KEYWORDS: Historical value, philosophy, conservation, biography.

856. Swift, Ernest F.
1951. Maintenance of the hunting and fishing sports. Wis. Conserv. Bull. 16(6): 3-6.

Author discusses some problems of the game management profession including lack of controls on the spreading hunter population, the impact of sportsmen on private lands, and public attitude. It is suggested that any one resource cannot be managed with disregard to others. To solve hunting and fishing pressures, one must have a broad picture of conservation in all its intricate patterns.

KEYWORDS: Fishing, management, resource use.

857. Swift, Lloyd W.
1959. Landowner-government roles in European wildlife management. 39th Conf. West. Assoc. State Game Fish Comm. Proc. 39: 67-73.

Hunting and fishing rights and ownership belong to the landowner in Europe. Countries set the hunting season and control the sale of game in the markets. Federal or State management is almost unknown, and protection, production, and management are up to the landowner. Countries mentioned include Yugoslavia, Norway, the Low Countries, the Mediterranean area, England, Scotland, West Germany, and Austria.

KEYWORDS: Foreign country-general, management, landowner-private.

858. ________
1961. Who hunts and fishes in Western Europe. 41st Conf. West. Assoc. State Game Fish Comm. Proc. 41: 15-19.

Paper gives an account of personal hunting experience and a description of hunting and fishing rights based on land ownership in Europe.

KEYWORDS: Foreign country-general, fishing, landowner-private.

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859. Taber, Richard D.
1961. Wildlife administration and harvest in Poland. J. Wildl. Manage. 25(4): 353-363, illus.

Described for Poland are the administration of game ownership, management units, hunting regulations and licenses, hunting societies and circles, hunting seasons for over two dozen species, game damage, recent developments in wildlife conservation, and wildlife institutions. Comparisons are made between Poland (a socialist nation) and West Germany (a democratic, capitalistic nation). A minute proportion (0.12 percent) of the Polish population hunt by North American standards. The hunting fraternity is an elite social group, and management is derived from the system of estates of 19th century aristocratic hunting traditions.

KEYWORDS: Poland, administration, management.

860. _________ Richard A. Cooley, and William F. Royce
1970. The conservation of fish and wildlife as natural resources in the United States, p. 143-151. *In* No Deposit, No Return, Huey D. Johnson [ed.]. Reading, Mass.: Addison-Wesley Publ. Co., Inc.

There are four interrelated problems in the use of fish and wildlife as natural resources in the United States: ownership, habitat, cropping, and husbandry. Discussion of each problem is followed by recommendations which include: the need for a broader base of responsibility for fish and game departments and appropriate funding to free them from dependence on sportsmen; an increase in research support; means to reverse habitat deterioration on private lands; effective pollution regulation; international cooperation and control; and control of human populations.

KEYWORDS: Management, conservation, economics, fishing.

861. Taft, A. C.
1947. Maintenance of angling in California. 12th Conf. North Am. Wildl. Trans. 12: 254-257.

An estimate of the total fish catch for California in 1944 was made by post-card questionnaires sent to 10 percent of the license holders. Only 25 percent responded. Questionnaires sent to nonrespondents revealed that 6 percent of the permittees never fished. Of those who went fishing, 11 percent made no catches and expressed the least satisfaction. Artificial production of fish is an expensive luxury. Of the $2 the sportsman spends each year, approximately $1 is used to provide about 12 percent of his total annual catch. Fishermen, accustomed to an annual bag of 71 fish, do not realize that this large number was not supplied by their $2. Sound management will come when this unrealistic view is counteracted. Cost figures correlated with catch are used to argue against fish stocking.

KEYWORDS: Fishing, management, California, economics.

862. Tallman, John D.
1956. The status of underwater spearfishing in the Puget Sound area of Washington. M.S. thesis, Univ. Wash., 164 p.

Questionnaires mailed to 260 known underwater spearfishermen (not sport divers) yielded a 53-percent return. Nearly 98 percent were men, median age

age was 24.5 years, over 30 percent began the sport in 1952 or later, almost 90 percent participate year round with almost 50 percent participating once a week, over half own scuba equipment retailing for about $160 ($100-200 was median expenditure for some 36 listed items of equipment), and about 60 percent belong to some 14 underwater spearfishing clubs. Twenty-four spearfishing areas in Puget Sound are listed, with areas close to Seattle the most popular. The ling cod is Puget Sound's most commonly speared fish. Fishermen get at least one fish on three of four trips. Only two-thirds had diving or water safety training. No State or local laws were found pertaining to underwater spearfishing. Rules, diving limits, and conduct codes are set by the director of the State Department of Fisheries. Survey results indicate most spearfishermen prefer no limitations on equipment (27 percent were against gas-powered guns), oppose fish planting, and 63 percent do not favor licensing. Recommendations are presented for the University of Washington Fisheries Department, the State legislature, underwater fishing clubs, surface anglers, sportsmen, and future research. A brief history is presented on surface spearfishing, swimming, and submarine diving with extended treatment of worldwide, U.S., and Puget Sound underwater spearfishing. (A unique topic with interesting historical material.)

KEYWORDS: Fishing, historical value, Washington, preferences, characteristics.

863. Tarzwell, Clarence M.
1941. A second season of creel census on four Tennessee Valley Authority reservoirs. 6th Conf. North Am. Wildl. Trans. 6: 202-221.

A creel census started in 1936 and expanded in 1940 obtained records on 47,030 fishing trips with a listed catch of over 158,000 fish weighing about 154,000 pounds, taken in about 234,000 hours at the rate of 0.7 fish per hour. On the area as a whole, 25 percent of the anglers failed to catch fish. Average fishing time was 5 hours; the average catch was 3.4 fish weighing 3.3 pounds.

KEYWORDS: Crowding, fishing, harvest statistics, surveys.

864. Taylor, Jim
1961. Let's even up the deer kill! Wis. Conserv. Bull. 26(1): 14-15, illus.

Author defends the party permit and suggests inclusion of a "variable quota" feature to assure adequate yearly deer harvest.

KEYWORDS: Big game, harvest statistics.

865. Taylor, John I.
1963. As the farm groups see the game departments. 43d Conf. West. Assoc. State Game Fish Comm. Proc. 43: 30-35.

Farmer and rancher criticize the game department's relationship with individuals and groups, their role in promoting wildlife and recreational opportunities, and their policies in land management, leasing, and buying.

KEYWORDS: Farmer-sportsman relations, administration, resource use.

866. Taylor, Lytton
1954. A factual press results in a conservation-minded public. 19th Conf. North Am. Wildl. Trans. 19: 555-562.

Managers are losing public support for policies because they are not

keeping the public informed. Conservation education can provide this information only if agencies provide material. Unskilled writers have failed to gain support for a shortened season--agencies cannot keep good newsmen. Civil Service regulations keep the wages of agency reporters lower than those of regular reporters. These regulations must be overruled, and agencies must become involved with public relations to get public support.

KEYWORDS: Conservation, education, public relations, communications.

867. Taylor, W. Hassell
1963. Game harvest and hunter use camp, A. P. Hill, Bowling Green, Virginia. 17th Conf. Southeast. Assoc. Game Fish Comm. 17: 168-172.

The Army's Camp A. P. Hill provides an excellent example of multiple use of military areas. With a two-deer (one of which may be a doe) bag limit, it has produced and sustained a high deer kill and a high hunter use for all recorded periods. Hunting pressure increased 816 percent in the 7-year period from 1954-62.

KEYWORDS: Resource use, management, harvest statistics, Virginia, military.

868. Taylor, Walter P.
1934. Significance of extreme or intermittent conditions in distribution of species and management of natural resources, with a restatement of Liebig's law of minimum. Ecology 15(4): 374-379.

Land use policies, range administration, forest conservation, and game protection should be adjusted not to average conditions, but to those poorer than average or extreme. Species are not adapted to average conditions but to very unfavorable conditions experienced from time to time. The maintenance of wildlife depends upon livable conditions at the period of most critical character.

KEYWORDS: Resource use, administration, management.

869. Teague, Richard D. (ed.)
1971. A manual of wildlife conservation. 206 p., illus. Washington, D.C.: Wildl. Soc.

Included are 49 papers in eight sections which include policy and administration, people and wildlife, wildlife management, fisheries management, wildlife law, wildlife and private land, wildlife research, and techniques for developing an effective short course.

KEYWORDS: Administration, non-consumptive use, management, legislation, landowner-private, education.

870. Teer, James G.
1952. Controlled waterfowl hunting on a State-owned public shooting ground, Forney Lake, Iowa, 1950. Iowa State Coll. J. Sci. 26(4): 541-553, illus.

During the 1950 waterfowl hunting season, 25 floating three-man blinds were distributed over the 489-acre shooting ground. A total of 1,704 hunters harvested 1,417 waterfowl--an average of 0.83 bird per man-day and 7.66 hours per bird. Eighty-two sportsmen harvested daily limits of ducks. Crippling loss amounted to 20.9 percent. Blind success varied according to hunter ability and equipment. Of 875 reservations issued, 382 or 56.3

percent used them. An increase in hunter numbers did not increase the total daily harvest. Of 235 parties questioned, 211 (89.2 percent) were satisfied with area management. Of 202 parties, 175 (86.6 percent) were in favor of the area remaining controlled. Hunters' greatest complaints concerned "sky shooting" and defects of the blinds. Total cost to the conservation commission was $2,415.37 or $1.41 per hunter. A 50 cent fee per day to be charged in 1951 should completely defray the cost of managing and operating the area.

KEYWORDS: Waterfowl, management, harvest statistics, economics, Iowa.

871. Texas Game and Fish
1953. Deer laws here and there. Tex. Game Fish. 11(12): 8-9, illus.

General summary is given of laws pertaining to deer hunting, including definition of a legal buck, legal weapons, license fees, calling devices, and other laws. Over 25 States are mentioned.

KEYWORDS: Big game, legislation, surveys.

872. Thomas, Jack Ward, and James C. Pack
1968. Joe Typical, profile of a hunter. Outdoor West Va. 32: 19-20, illus.

A 1967 interview study of 1,353 hunters in West Virginia yielded the following profile of the typical hunter. He was a resident nearly 40 years of age with 19 years of experience. He traveled 110 miles to reach his favorite hunting spot and primarily hunted deer with a shotgun. He spent 8 hours of hunting effort for each deer he saw and 167 hours for each deer he killed.

KEYWORDS: West Virginia, characteristics.

873. Thompson, Emmett F., James M. Gray, and Burd S. McGinnes
1967. Estimated hunting expenditures in Virginia. Va. Polytech. Inst. Dep. For. Wildl. Res. Rep. 116, 8 p., illus.

A mail questionnaire was sent to 1,800 resident and non-resident sportsmen in Virginia. Analysis is based upon a 40-percent return. The average hunter spent $233 for his hunting activity and $87 million was estimated as the total expenditures by hunters.

KEYWORDS: Virginia, economics.

874. Thompson, Jesse F.
1948. The public must be educated to the knowledge that legislation and regulation constitute the management of their fish and wildlife resource. 38th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 38: 135-138.

Paper discusses briefly the need to control man's predations by better public relations.

KEYWORDS: Public relations, education, management, conservation.

875. Thornton, J. E.
1969. Big Levels--a game management laboratory. Va. Wildl. 30(2): 4,5,23, illus.

Big Levels was established as a game refuge in 1938, but later the

ban on hunting was removed. It is now a testing ground for many new techniques, ideas, and regulations.

KEYWORDS: Refuge, Virginia, management.

876. Threinen, C. W.

1955. Where is sport fishing headed? Wis. Conserv. Bull. 20(2): 23-24, illus.

With proper management, in the year 2000, Wisconsin will host 2,000,000 resident and non-resident anglers. Each angler will have an average of half an acre of water and 50 pounds of fish with which to try his luck.

KEYWORDS: Fishing, Wisconsin, management.

877. Throckmorton, Michael

1958. Some special educational projects of service to sportsmen. 38th Conf. West. Assoc. State Fish Game Comm. Proc. 38: 348-353.

Paper lists and analyzes the educational responsibilities of Idaho's Information and Education Division. Topics included are farmer-sportsman relations, conservation workshops, firearms safety, youth education, and clubs.

KEYWORDS: Idaho, education, farmer-sportsman relations.

878. Tillett, Paul

1963. Doe day: the antlerless deer controversy in New Jersey. 126 p., illus. New Brunswick, N.J.: Rutgers Univ. Press.

Controlling the deer population through antlerless deer hunting seasons led to controversy among groups including landowners, sportsmen, farmers, wildlife managers, motorists, newspaper columnists, governmental agencies, and finally the State supreme court. This book traces the debating and politicking over the shooting of doe deer and the personalities involved over a 3-year period.

KEYWORDS: Big game, Federal-State jurisdiction, either-sex hunt, New Jersey, farmer-sportsman relations, politics.

879. Tindall, Barry S.

1968. Aldo Leopold--a philosophy and a challenge. Parks Rec. 3(10): 28-30, illus.

The philosophy, writings, and achievements of Aldo Leopold carry a plea for recreational experiences of the highest order which deserve more attention from professionals in parks and recreation.

KEYWORDS: Conservation, non-consumptive use, philosophy.

880. Titcomb, John W.

1931. State control of fishing waters. 23d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 23: 21-28.

Paper describes how Connecticut leased 4-year fishing rights from rural landowners at a nominal sum and a fair 10-year or all-time-basis renewal price.

KEYWORDS: Fishing, landowner-private, Connecticut, lease.

881. Titus, Harold

1951. Effects of political interference on wildlife administration. 41st Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 41: 78-82.

One problem facing wildlife managers is the continual meddling of statesmen. Opposition to the statemen's "conservation ideas" can cause the loss of legislative approval for a bureau's budget. Types of "self-proclaimed conservationists" include: those not concerned with wildlife but with political gains, those concerned with wildlife but skeptical of trained personnel, and those not directly in the legislature yet influencing it. Elected managers must play political games to keep thier position.

KEYWORDS: Legislation, administration, politics.

882. _________

1958a. Farewell to free hunting? Field Stream 63(8): 37-39, 104-105, illus.

Landowners are rapidly recognizing the advantages of charging for public hunting on privately owned land. Paid shooting preserves restrict the number of hunters per area and often allow a larger bag limit of pen-reared birds than on public areas.

KEYWORDS: Landowner-private, refuge, farmer-sportsman relations, plant and shoot.

883. _________

1958b. More hunting for everyone. Field Stream 63(4): 47, 107-109.

Wildlife researchers have recommended longer seasons or increased bag limits in some areas to keep the game supply at its best. Sportsmen who do not understand concepts of range carrying capacity will be confused, since many of them believe that large bags one year will always mean less game the next.

KEYWORDS: Conservation.

884. _________ and George Laycock

1955. Is public hunting doomed? Part II. Field Stream 60(7): 82-84, 172-176, illus.

One-third of the Nation's hunters live in the 13 North-central States, where for every acre of free public hunting there are 23 acres of restricted hunting. Even with 11 million acres in National Forests and 11 million in State-owned or -leased forests, there is not enough to meet demand. Private pay-as-you-shoot areas absorb some of the demand. Illinois feels the greatest pressure for more hunting opportunity. Pheasants are stocked and the hunter buys a license and pays $4 a day for pheasant hunting. North Dakota, by contrast, has a great deal of good hunting land, but landowners are beginning to lease it to clubs. Other North-central States have met hunting demand by forming farmer-hunter cooperatives, promoting self-help programs, and buying land outright. Private shooting preserves are very popular in this region, but only 4 percent of the land is free public range. (Also see part I (Anonymous 1955) and part III (Page and Camp 1955) of this series.)

KEYWORDS: Landowner-private, farmer-sportsman relations, surveys, upland game birds, waterfowl, user-fee, plant and shoot, access.

885. Tody, Wayne H.
1970. Zones for the big lakes. Mich. Dep. Nat. Resour. 39(2): 3-9, illus.

In 1964 Michigan's fisheries were below par, and fishing license sales declined due to poor quality lake fish. The development of sport fishing on the Great Lakes has improved the fishery. A zone management plan designates three types of water areas: sport fish development zones, rehabilitation zones, and commercial fishing zones. Recreation and commerce are challenged to become complementary.

KEYWORDS: Fishing, resource use, Michigan, Great Lakes.

886. ________ and Howard A. Tanner
1966. Coho salmon for the Great Lakes. Mich. Dep. Conserv., Fish Div. Fish Manage. Rep. No. 1, 38 p., illus.

The ultimate aim of introducing coho to the fresh-water environment of the upper Great Lakes is to convert an estimated annual production of 200 million pounds of low value fish into an abundance of sport fish for recreational fishermen and to restore the depressed commercial fisheries to a productive and economically viable industry. (An excellent fisheries management plan is discussed in detail, but all primary considerations are biological.)

KEYWORDS: Fishing, management, Great Lakes.

887. Toler, Harris
1961. Definition: public fishing rights. Tex. Game Fish. 19(7): 4-5, 27.

Laws and Supreme Court rulings pertaining to Texas fishing rights are explained.

KEYWORDS: Texas, legislation, fishing.

888. Tomlinson, George E.
1961. Meeting the needs for hunting and fishing in the southeast river basins. 51st Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 51: 57-64.

Demand for hunting and fishing in the United States is predicted to increase 2½ times by the year 2000; and although the overall resource potential is great enough to meet it, State and Federal agencies in the southeast river basins may be confronted with financial crises as demands for better accommodations and more assured harvests increase.

KEYWORDS: Fishing, surveys, economics.

889. Towell, William E.
1967. Do residents control resident game? Am. For. 73(7): 20-21, 40-41, illus.

One of the hottest States' rights issues in a quarter century concerns the regulation of the harvest of fish and resident game on Federal lands. States are jealous of their historical prerogatives to set seasons and limits. Private land is increasingly going into Federal ownership, and much of it will be closed to public hunting. Current legislation in

Congress which strongly favors the States' position is discussed in its historical perspective.

KEYWORDS: Federal-State jurisdiction, resource use, legislation, historical value.

890. Towles, Harry, and Ronnie Rhody
1955. A well rounded informational and educational program for fish and wildlife departments. 9th Conf. Southeast Assoc. Game Fish. Comm. Proc. 9: 119-123.

Paper encourages and describes full public relations by fish and wildlife agencies.

KEYWORDS: Public relations, education.

891. Trefethen, James B.
1961. Crusade for wildlife. 377 p., illus. New York: Boone and Crockett Club.

This text is an excellent historical reference on wildlife conservation in the United States with focus on the formation, development, and growth of the Boone and Crockett Club. The emergence of sportsmanship is described, along with details on the development of the club's big game trophy records of North America. Details are given on the club's role in setting aside Yellowstone and Galcier National Parks as wildlife sanctuaries, as well as in the formation of the National Forest System and the Wildlife Refuge System. The club was instrumental in the formation of many State game and sportsman policies, legislation, and international wildlife treaties. It was the first to speak against the bounty system on predators and market hunting. The roles of Theodore Roosevelt, Gifford Pinchot, and many others in the conservation field are generously described.

KEYWORDS: Conservation, legislation, commercial hunting, historical value, resource use, predator.

892. Trippensee, R. E.
1939. Wildlife management in the United States: past, present and future. For. Chron. 12(4): 375-381.

Author surveys the highlights of wildlife history and development including past interest and growth in wildlife management, the struggle to same wildlife from extinction, and recent developments in wildlife conservation, research, education, and demonstration.

KEYWORDS: Management, historical value, conservation.

893. Tucker, William J.
1933. Is it wise to tinker with the legal status of game? 25th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 25: 125-130.

Author criticizes the European system of game management wherein the state surrenders game control to the landowner. Advocates licensed shooting preserves on private property where the state maintains control of game.

KEYWORDS: Refuge, Texas, Federal-State jurisdiction.

894. Tucker, Wm. J.
1943. Shooting preserves pay off. Tex. Game Fish. 1(4): 6-7, 17, illus.

Article describes Texas' pioneer efforts in a sportsman-landowner cooperative system.

KEYWORDS: Historical value, Texas, Farmer-sportsman relations, refuge, economics.

895. Tulane, Roy G.
1953. State's rights in controlling the destiny of interior rivers. 43d Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 43: 128-135.

Paper shows how the Federal Government acquired jurisdiction over all the rivers in Wisconsin. Cooperation between State and Federal agencies resulted in a solution to the question of whether or not to construct a dam on the Namekagon River.

KEYWORDS: Federal-State jurisdiction, conservation, Wisconsin.

896. Turner, David B.
1948. Professional opportunities in the wildlife field. 208 p. Am. Nature Assoc. & Wildl. Manage. Inst.

This somewhat dated text has historical value. Topics covered include individual training, institutions of higher education, and Federal, State and provincial employment. (Bibliography, 21.)

KEYWORDS: Profession, education, Canada.

897. Twiss, Robert H.
1967. Wildlife in the metropolitan landscape. 32d Conf. North Am. Wildl. Nat. Resour. Trans. 32: 69-74.

Landscape is significant not in its superficial appearance but in its deepest meaning. We must consider the richness of the landscape, its natural processes, its history, and its scenery as an environment for human drama. Resource development should consider spatial arrangement and visual form and a response to functional tasks. Research questions into the human response to the landscape include: what attracts attention, what can most observers identify, what do observers prefer, and what is memorable? Resource managers should solicit design talent for their projects and thus hasten the application of ecosystem evaluation and management in the metropolitan setting.

KEYWORDS: Esthetics, research needs, non-consumptive use, resource use, urban wildlife.

898. Tyre, Gary L., and George A. James
1971. Length and rate of individual participation in various activities on recreation sites and areas. USDA For. Serv. Res. Note SE-161, 4 p. Southeast. For. Exp. Stn.

Statistically reliable methods for estimating recreation use on large areas exist, but these often prove prohibitively expensive. Alternatives utilizing length and rate of individual participation in specific activities are presented. Data were obtained from interviews of 7,186 recreationists

from June 13 through October 8, 1966, on the Eldorado National Forest, California; 10,219 recreationists from June 15 through September 4, 1967, on the Toiyabe National Forest, California-Nevada; and 8,144 recreationists from May 15 through September 9, 1969, on the Ashley National Forest, Utah-Wyoming. There were 12,028 persons engaged in fishing, and these represented a 47-percent participation rate, with a mean length of stay of 5.8 hours excluding sleep time. There were 1,194 persons engaged in hunting, and these represented a 4.6-percent participation rate with a mean length of stay of 7.6 hours. Twenty-one other activities are listed, including nature study.

KEYWORDS: Fishing, California, Nevada, Wyoming, Utah, crowding.

U

899. Uhlig, Hans G.
1961. Survey of leased waterfowl hunting rights in Minnesota. J. Wildl. Manage. 25(2): 204.

Survey of 49 waterfowl hunting leases on 3,919 acres showed cash value of hunting rights averaged $5.10 per acre. Almost half the landowners received an average of $1.45 per acre. Highest priced leases of $13 per acre netted the same profit as cropland acreage. Size of area had little to do with cost of lease. Outside hunters paid three to five times the lease price of local hunters.

KEYWORDS: Economics, landowner-private, waterfowl, Minnesota, lease.

900. Underhill, A. Heaton
1958. Hunting and fishing opportunity in an industrial society. 48th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 48: 63-66.

Future hunting opportunity in New Jersey will be founded on public lands, and clean water will be the primary provision for good fishing. Fish and game administrators must demonstrate integrated planning and the public must pay to preserve its outdoor heritage.

KEYWORDS: New Jersey, fishing, conservation.

901. ________
1967. Bureau of Outdoor Recreation and Hunting and Fishing. Remarks at the Fontana Conservation Roundup, Fontana Dam, North Carolina, May 19, 1967. Bureau of Outdoor Recreation. 4 p.

The role of hunting and fishing in outdoor recreation programs is explained. Hunters and fishermen must join with wilderness lovers, foresters, municipal park planners, and local legislators to plan wisely. To the maximum extent possible, the various outdoor interests must be coordinated to pool resources. Outdoor recreation can and should become the rallying point for the development of some non-consumptive uses of fish and wildlife, for wise land use, for sound conservation practices, and other long-range objectives in order to realize an environment that really enhances the joys of living. (Condensed from "Index of Selected Outdoor Recreation Literature," volume three, by Bureau of Outdoor Recreation.)

KEYWORDS: Non-consumptive use, management, fishing.

902. ________ Harry R. Woodward, Charles S. Collins, and Fred L. Jones
1965. The role of fish and wildlife in outdoor recreation. 55th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 55: 78-91.

A series of four articles describes the place or role of fish and wildlife in recreation, presented from the viewpoint of the Federal, State, county park, and State park administrators.

KEYWORDS: Non-consumptive use, administration, fishing.

903. U.S. Bureau of Sport Fisheries and Wildlife
1955. National survey of fishing and hunting. USDI Bur. Sport Fish. Wildl. Serv. Circ. 44, 50 p., illus.

In 1955, 20,813,000 sport fishermen spent $1,914,292,000 and 397,447,000 recreation days, taking 341,333,000 trips and traveling 17,910,434,000 miles by automobile. The 11,784,000 hunters spent $936,687,000 and 169,423,000 recreation days, taking 154,370,000 trips and traveling 6,072,296,000 miles by automobile. In 1955, 18,420,000 fresh water fishermen spent $1,425,353,000; 4,557,000 salt water fishermen spent $488,939,000; 1,986,000 waterfowl hunters spent $118,745,000; 9,822,000 small game hunters spent $494,033,000; and 4,414,000 big game hunters spent $323,909,000. Approximately 20,000 households were sampled in each of the 48 States, yielding interviews with 6,220 fishermen and 3,108 hunters.

KEYWORDS: Economics, fishing, surveys, characteristics.

904. ________ 1961. 1960 National survey of fishing and hunting. USDI Bur. Sport Fish. Wildl. Serv. Circ. 120, 73 p., illus.

In 1960, 25,323,000 sport fishermen spent over $2.6 billion and spent 465,796,000 days fishing. They took 412,343,000 trips and traveled over 18.8 billion miles by automobile. The 14,637,000 hunters spent over $1.1 billion and spent 192,539,000 days hunting. They took 178,284,000 trips and traveled over 7.6 billion miles by automobile. Sportsman expenditures are broken down by fresh water fishermen, salt water fishermen, and waterfowl, small game, and big game hunters. Approximately 45,000 persons 12 years of age and older were chosen in the national sample, and detailed interviews were completed with 6,500 fishermen and 3,800 hunters. Comparison of data is made with the 1955 national survey of fishing and hunting.

KEYWORDS: Economics, fishing, surveys.

905. ________ 1965. National survey of fishing and hunting. USDI Bur. Sport Fish. Wildl. Serv. Res. Pub. No. 27, 76 p., illus.

Personal interviews with 6,400 individuals are summarized in a subsample of the U.S. labor force in a monthly survey by the Bureau of the Census. Included are only those sportsmen who had fished or hunted at least any part of 3 days or spent $5 or more to go fishing or hunting during 1965. Details include the different types of fishing and hunting by the money and recreation days spent, the number of trips, places of residence, income, occupation, and license status. In 1965, U.S. sport fishermen numbered 28,348,000, spent $2,925,304,000, spent 522,759,000 recreation days, took 451,449,000 trips, and traveled 22,719,918,000 passenger miles. In 1965 hunters numbered 13,583,000, spent $1,121,135,000, spent 185,819,000 recreation days, took 169,327,000 trips, and traveled 8,659,034,000 passenger miles. (Popular presentation of survey results in simplified pictorial graph form along with extensive tables giving details of results.)

KEYWORDS: Fishing, economics, surveys, characteristics.

906. ________ 1970. Selected list of Federal laws and treaties relating to sport fish and wildlife. USDI Bur. Sport Fish. Wildl. Serv. WL-489, 4 p.

The 36 Federal conservation laws most commonly associated with the protection and management of wildlife are referenced. Acts are listed and their provisions briefly described. Starting with the Lacey Act of 1900, it ends with the Endangered Species Conservation Act of 1969.

KEYWORDS: Management, legislation, historical value.

907. ________
1971. Sport fishing USA. USDI Bur. Sport Fish. Wildl. Serv., 464 p., illus.

A comprehensive discussion of sport fishing includes essays on fish biology, the equipment and techniques of angling, places to fish, fish management practices, environmental pollution and quality problems, and economic benefits. The latter reviews data from national surveys of fishing and hunting. Reports on boating activity in relation to fishing and various fisherman expenditure reports substantiate the knowledge that anglers are growing rapidly and that their expenditures are in the billions of dollars.

KEYWORDS: Fishing, access, non-consumptive use, benefits, economics, research methods, resource use, surveys.

908. ________
1972. 1970 National survey of fishing and hunting. USDI Bur. Sport Fish Wildl. Serv. Resour. Publ. 95, 108 p., illus.

In a mail-questionnaire screening survey, results showed that among those Americans aged 9 years or older, almost 55 million fished, hunted, or both, and spent 779 million days in recreation. Seven million Americans birdwatched, and 5 million photographed wildlife. A second interview-survey revealed that more than 33.1 million Americans hunted and 14.3 million participated in fishing. The fishermen spent $4.9 billion and fished a total 706 million days. Hunters numbered over 14 million and spent $2.1 billion on equipment, bait, guides, food, lodging, transportation, and licenses. Detailed tables are presented for deomgraphic variables, game pursued, and sportsman expenditures.

KEYWORDS: Fishing, economics, surveys, characteristics.

909. U.S. Department of Agriculture
1964. The principal laws relating to the establishment and administration of the National Forests and other Forest Service activities. USDA Hand. No. 20, 127 p.

Laws related to wildlife include: (1) 1908, "Enforcement of State laws relating to livestock, forest fires, and wildlife," (2) 1916, "Game refuges," and (3) 1959, "Use of aircraft or motor vehicles prohibited for hunting certain wild horses or burros; pollution of watering holes."

KEYWORDS: Legislation, administration.

910. U.S. Outdoor Recreation Resources Review Commission
1962a. Hunting in the United States - its present and future role. ORRRC Study Rep. 6, 117 p.

Study comments on history of hunting, the future supply of huntable game such as the kinds and amounts of game, where it will be found, conditions of the hunter's access to it, the trends that have influenced hunting

in the past and are likely to influence it in the future, and the significance of land use changes and ownership patterns. Study makes "no pretense of being quantitative," but many demographic and resource statistics are presented in tabular form. Also presented are land use and wildlife characteristics of nine study regions in the United States.

KEYWORDS: Historical value, management, economics, resource use, surveys.

911. ________
1962b. Sport fishing - today and tomorrow. ORRRC Study Rep. 7, 127 p., illus.

During the decade from 1950 to 1960, increase in resident license holders was twice the population increase. Almost 30 percent of all males over 12 years of age are fishermen, and 10 percent of the females. Only 9.8 percent of the inhabitants of big cities are anglers. In towns and rural areas 21.4 and 24.6 percent, respectively, are fishermen. Current trends indicate 63 million anglers will fish 1.3 billion days by year 2000. Increase in fishing demand can be met with only slight reductions in the average catch by adding new waters (mostly new impoundments and farm ponds), by better management of existing waters, and by more fishing in coastal waters. The survey reveals data on fishing as a form of recreation, the status of fishing waters in 1960, problems of supply, management policies and responsibilities, sport fishing in the years ahead--1976, 2000-- and a summary of prospects for regions of the country. Social and economic advancements, technological changes, and population expansion have caused many adjustments in the concepts of sport fishing. Angler overcrowding apparently appeals to the gregarious nature of a sizable segment of the fishing public. Anglers normally accept crowding if fishing is good. Much biological and management information was gained by questionnaires sent to all 50 State game departments. All 50 States responded.

KEYWORDS: Economics, fishing, historical value, management, preferences, surveys.

912. U.S. Senate Committee on Commerce
1965a. Compilation of Federal laws relating to the conservation and development of our Nation's fish and wildlife resources. 89th U.S. Congr., 1st Sess., 472 p.

KEYWORDS: Legislation.

913. ________
1965b. Treaties and other international agreements containing provisions on commercial fisheries, marine resources, sport fisheries, and wildlife to which the United States is party. 89th U.S. Congr., 1st Sess., 410 p.

KEYWORDS: Legislation, foreign country-general.

914. ________
1970. Treaties and other international agreements on oceanographic resources, fisheries, and wildlife to which the United States is party. 91st U.S. Congr., 2d Sess., 672 p.

KEYWORDS: Legislation, foreign country-general.

V

915. Van Den Akker, John B., and Vanez T. Wilson
1951. Public hunting on the Bear River Migratory Bird Refuge, Utah. J. Wildl. Manage. 15(4): 367-381, illus.

A refuge checking station operating since 1932 has yielded the following. Setting hunting dates to miss the presence of protected species is more effective than differential bag limits; bag limits affect bag averages little but they do affect total kill. The most important factor in total kill is the number of hunter days spent in the field. The split season and the State optional open-season dates permit longer seasons and increase the enforcement problem. Standard starting and closing times should be 7 a.m. and 4 p.m. The average bag for the years 1932-48 was 3.5 birds per hunter day. Hunter success is proportional to bird population density, hunting skill, and the quality of equipment.

KEYWORDS: Crowding, waterfowl, refuge, harvest statistics, Utah.

916. Van Dresser, Cleveland
1956. Elbow room for sportsmen. Am. For. 62(7): 18-19, 46, illus.

Florida's public hunting program has created a sportsman's paradise by opening 2 million acres to hunters and anglers while keeping the landowner happy.

KEYWORDS: Landowner-private, Florida, fishing, access.

917. ________
1959. Multiple use wildlife refuge. Am. For. 65(3): 20-21, 46-48, illus.

St. Mark's refuge is primarily a wildlife sanctuary. It also serves as a public recreation area by providing boating, fishing, waterfowl shooting in season, and historical points of interest.

KEYWORDS: Refuge, Florida, resource use, waterfowl.

918. Van Etten, Robert C., D. F. Switzenberg, and Lee Eberhardt
1965. Controlled deer hunting in a square-mile enclosure. J. Wildl. Manage. 29(1): 59-73, illus.

Seven annual controlled hunts (1954-60) conducted in a square-mile fenced enclosure in northern Michigan show quantitatively what proportion of a white-tailed deer herd a hunter may see and bag under various hunter conditions and deer concentrations. Results indicate that deer are usually more plentiful than seems evident to the casual observer. In 1954, a party of six hunters required 124 man-hours (15½ man-days) of hunting even to see a buck, although seven were known to be on the square mile hunted. Over the seven years, hunters on the average saw a deer every 1.3 hours, but bucks were seen only every 18 hours of hunting time. "Good" days were correlated with large number of sightings. Still-hunting or stalking was the most popular method of hunting, but driving was most effective means per unit of effort for killing deer. No bucks were ever seen on a drive.

KEYWORDS: Big game, management, research methods, harvest statistics, Michigan.

919. Van Orden, George O.
1945. Retraining the returned G.I. to shoot safely. 10th Conf. North Am. Wildl. Trans. 10: 53-61, illus.

Tests on 5,000 rehabilitating Marine war veterans at Klamath Falls, Oregon, revealed lack of firearm safety knowledge and skill. Most rated themselves better shots than the test revealed. About 60 percent expressed desire to hunt with either rifle or shotgun after the war, and 81.3 percent expressed interest in competitive shooting. They showed poor marksmanship (compared with N.R.A. standards), and a test of 824 men showed declining marksmanship with increased years of service. (Testing procedure and research incompletely described.)

KEYWORDS: Safety.

920. Vessels, Jay
1952. King of the market hunters. Tex. Game Fish. 10(12): 11-14, illus.

A story is told of an 86-year-old named Nat Wetzel who was one of the world's biggest commercial agents in wildlife half a century ago. He insists that the decline in wildlife populations resulted from encroachment of civilization, not from market hunting. Wetzel is described as the big game, frog, onion, and melon king. He trained hunters in the art of catching frogs which grossed $50,000 a year in two States.

KEYWORDS: Commercial hunting, historical value, big game.

921. Vilkitis, James R.
1968. Characteristics of big game violators and extent of their activity in Idaho. M.S. thesis, Univ. Idaho, 202 p., illus.

Questionnaires mailed to 874 randomly selected big game hunters and to 874 convicted violators yielded 38.4-percent returns from violators and 51.5 percent from hunters. Interviews of 32 violators and 29 sportsmen supplement questionnaires. Violators were more likely than hunters to be male, not own a telephone, of age 20-29 years, have an elementary school education, married, three dependents under 18 years, rent, be industrial workers, hold more than one job, be less conscious of class structure, spend more time on public land, and prefer to hunt over other forms of recreation. Violators were more likely than hunters not to turn in violations by strangers. Both were unwilling to report a friend for violating. Personal interviews revealed that violators, contrary to hunters, thought hunter crippling losses were higher, that game laws were well enforced, and that a higher percentage of violators were not apprehended. Differences in age, income, marital status, and family between closed-season violators and open-season violators are presented. Of all arrests for big game violations, 62.2 percent involved deer, 12.2 percent elk, 3.4 percent moose, 3.1 percent antelope, 0.5 percent bear, 0.4 percent sheep, and 0.1 percent goat. Checking station violations constituted 10.5 percent of all citations. Violations include 66.2 percent for unlawful procedure, 23.6 percent for closed season, 3.5 percent for over the limit, 1.3 percent for illegal gear, 2.3 percent for no season, and 3.1 percent for no license. The majority of hunting season arrests occurred on weekends, while the majority of closed season arrests occurred on weekdays. Hunting season citations, in general, were increasing, while the average fine was decreasing. An effort to determine the ratio of violators to nonviolators per arrest was unsuccessful. Conclusion is that the hunting public, although opposed to violations, will condone them. (Thesis emphasizes description of research

methods and design, but severe non-response bias may exist. Literature cited, 1.)

KEYWORDS: Enforcement, research methods, preferences, characteristics, Idaho, law violation.

922. Vogt, William

1961. The management of human populations. 26th Conf. North Am. Wildl. Nat. Resour. Trans. 26: 4-18.

Control of man, the most dynamic animal in the environment, is lacking. Population is discussed in its historical, cultural, religious, economic, and educational aspects. Motivation is cited as a major problem. An astounding ignorance of human anatomy, physiology, and the reproductive process is revealed. Abortion, sterilization, taxation, and restriction on immigration are suggested control methods.

KEYWORDS: Crowding, education, historical value, management.

923. Vogtman, Donald Benjamin

1942. Results of a controlled shoot on the Soap Creek experimental pheasant area, Corvallis, Oregon, October, 1941. M.S. thesis, Oreg. State Coll., 70 p., illus.

Simple management practices and total hunting protection over a 5-year period justified a controlled pheasant harvest. Only 27 permits were issued for the experimental area. Average shooting distance was 36 yards and 329 shots were fired, but 75 percent of the shots missed their mark. Average crippling loss was 39.4 percent. Farmers showed little interest in monetary return but were interested in controlling unrestricted hunting on their lands. The history of controlled hunt programs in other States is discussed.

KEYWORDS: Historical value, Oregon, upland game birds, farmer-sportsman relations.

924. Vorderstrasse, Roger Ernest

1955. Hunting deer with bow and arrow in the McDonald Forest, Oregon. Oreg. State Coll. M.S. thesis, 51 p., illus.

Descriptive study used 2,520 checking station records, field observations, hunter report cards, and mail questionnaires to 59 successful hunters during 1953 and 1954 seasons. Data revealed 32 shots per kill, 50 percent of hunters getting shots, 4.2 percent successful archers, 195 hours hunted per kill, 34 yards average length killing shot, and about 70 yards traveled by mortally hit deer. Details are given on arrow hit location, organs injured, arrow penetration, blood trails, sex-age classes of deer, equipment used, two accidents, hunter and landowner complaints, etc.

KEYWORDS: Big game, archery, harvest statistics.

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925. Wagar, J. V. K.
1947. The contest for western public game fields. J. For. 45(5): 323-328.

Sympathy for the interests of cattle ranchers, settlers, hunters, fishermen, and public land management agencies is maintained throughout this review of the current public land contest between the livestock industry, public land agencies, and the public itself. Author suggests problems that will arise if certain legislation proposed by stockmen and backed by the Chamber of Commerce becomes law. Caution and full examination of the facts are advocated before policies are enacted that may cause further conflict in use and deterioration of resources.

KEYWORDS: Landowner-public, legislation, historical value, resource use.

926. Wagner, Fred H.
1954. Public hunting grounds. Wis. Conserv. Bull. 19(8): 18-21.

Public hunting grounds provide extra space when other areas become too crowded. Wisconsin ranks high in providing hunting areas for its sportsmen.

KEYWORDS: Wisconsin, landowner-public, landowner-private, resource use.

927. Waldbauer, Eugene Charles
1966. A study of posting on private lands in New York State. Ph.D. diss., Cornell Univ., 278 p.

This is a study of private land posting from 1962-65 in 100 randomly selected towns in New York State. Investigation consisted of qualitative and quantitative aspects of posting and motivation. Results showed 26 percent of huntable State land posted by absentee, second party, full-time farmers, and rural nonfarm owners. The Hudson Valley-Catskill area had the largest (52 percent) amount of posted land. Poster condition, message, materials, cost, and legality were also studied. Interviews with 361 or 5 percent of the landowners in each ownership category show that the primary reasons for posting were: protection from large groups, personal and family safety, damage to fences, desire to have private game available, and hunter shooting near buildings. Although 83 percent of the landowners would allow friends and relatives to hunt, only 50 percent would permit strangers on land. Eighty percent of the owners were more concerned about regulating hunter behavior than in stopping hunting entirely. Very few owners were interested in pay or other incentives which might encourage them to allow public hunting. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Lease, landowner-private, preferences, economics, access, New York.

928. Wallace, Robert F.
1952. Economic aspects of wildlife resources of the State of Washington. Wash. State Coll. Econ. Bus. Res. Bull. No. 19, 42 p.

In 1950 an estimated $100 million was spent for wildlife or in its pursuit. Of this sum, $80 million was spent by the State's 400,000 resident licensees, who averaged about $200 each. In popularity, fishing ranked first, then big game, upland game, and waterfowl last, with sportsmen spending $125, $88, $74, and $60, respectively, in each pursuit. Hunting expenditures are broken into 16 goods and service categories, and these

totals are compared with other industries in the State. Washington wildlife, in 1950, represented nearly 20 percent of all agricultural income. (Condensed from a review by Lee E. Yeager in *Journal of Forestry* 51(1): 37-38.)

KEYWORDS: Economics, Washington, benefits, research methods, fishing.

929. ________

1956. An evaluation of wildlife resources in the State of Washington. Wash. State Coll. Econ. Bus. Res. Bull. No. 28, 63 p., illus.

A questionnaire was mailed to 1,051 sportsmen. The response after one followup letter, telephone calls, and personal interviews was 851, or 81 percent of the sample. Returns indicate that the average licensed sportsman spent $152 in 1954. License expenditures of $3 million bring the sportsmen's total outlay to $71 million. Fishing brought in the most money, with 79 percent of the respondents reporting average expenditures of $116. Big game hunting had 50 percent of respondents reporting an average $67 expenditure. Upland game accounted for 36 percent of respondents and $54 average, and waterfowl 22 percent and $41. When the $71 million spent by sportsmen is combined with the $25 million paid to Washington commercial fishermen for their 1954 catch, $96 million was spent that year for wildlife or in its pursuit. Comparisons are made between the amount of money paid for wildlife resources and the amounts paid for other crops, products, and services during a similar period. Such data afford a basis for observing the economic importance consumers attach to wildlife in comparison with farm crops or the retail trade. Evaluation of wildlife resources in other States is discussed.

KEYWORDS: Fishing, economics, Washington, benefits.

930. Walsh, Clark B.

1957. Do you see red? Oreg. State Game Comm. Bull. 12(1): 3, 6, illus.

Preanalysis results of a series of tests conducted at Fort Lewis in Washington State suggest that yellow is preferable to red as a color to wear for safety while hunting.

KEYWORDS: Safety.

931. Walters, D. W.

1957. The methods used in Alabama in combating the hunting of deer at night. 11th Conf. Southeast. Assoc. Game Fish. Proc. 11: 378-393.

Ten different papers each deal with ways to prevent headlighting or hunting deer at night. Conservation officers from the following States present what their State is doing: Alabama, Arkansas, Florida, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, and Tennessee.

KEYWORDS: Big game, law violation, enforcement, Alabama, Arkansas, Florida, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee.

932. Wandell, Willet N.

1946. An intensive method of determining hunter numbers and activities. 11th Conf. North Am. Wildl. Trans. 11: 373-382, illus.

A method of hunter census based on report cards was devised and used in 1940-43 on a 6,000-acre Massachusetts area during the course of an intensive

investigation of ring-necked pheasant populations. Hunters were divided into two groups: resident and transient. Residents were contacted before the season and asked to record their hunting activities. Transient hunters were contacted or their cars were tagged. Approximately four out of five cards distributed to transient hunters were returned with usable data. The accuracy of the information supplied, according to field checks, was high. Resident hunters need frequent reminders to keep their cards up to date. The cost for a 30-day season was $1.29 per square mile.

KEYWORDS: Research methods, Massachusetts.

933. Ward, Charles L.
1957. Wildlife educational information desired by Colorado sportsmen from State game managers. M.S. thesis, Colo. Agric. Mech. Coll., 184 p.

Mail questionnaires sent to 505 resident hunters yielded a very low 11.5-percent return and indicated that transplanting and information on exotic species, trophy information, and history of game were desired by respondents. Posting and access to private land was a "pet peeve." Boy Scouts, a rod and gun club, and an American Legion Chapter added 123 questionnaires. Content for a pamphlet includes distribution, life history, habitat, and management of nine big game and 16 upland game animals. (Fairly good discussion of need for more communication and public relations in wildlife management. Questionnaire included. References, 137.)

KEYWORDS: Education, Colorado, preferences, historical value.

934. Watt, Richard Darrell
1966. The recreational potential of the Arctic National Wildlife Range. M.S. thesis, Univ. Alaska, 103 p., illus.

The Arctic National Wildlife Range was studied for 42 days of field travel. The minimum cost for two people to spend 10 days on the range was approximately $450. Feasible activities include backpacking, mountain climbing, photography, canoeing, hunting, and fishing. Of 298 questionnaires received from recreationists, 199 indicated an interest in visiting the Arctic Range. Their primary reason was backpacking, followed in ascending order by photography, mountain climbing, canoeing, fishing, science, and hunting. A zoning system of management is recommended, with one area to be in the National Wilderness Preservation System and another to be reserved for utilitarian uses. Also given are a history of the establishment of the refuge, including congressional hearings; a physical description of the area; details on equipment, rates of travel, food and supplies needed for the activities mentioned above; and guidelines for administrative planning.

KEYWORDS: Alaska, non-consumptive use, refuge, economics, historical value, administration, legislation.

935. Weatherby, Roy E.
1963. As a sporting goods manufacturer sees us. 43d Conf. West. Assoc. State Game Fish Comm. Proc. 43: 60-62.

Manufacturer suggests caliber and energy restrictions be placed on hunting weapons, and that the government's 11-percent excise tax on firearms and ammunition be transformed into a more expensive hunting license.

KEYWORDS: Economics, license fee, equipment.

936. Webb, William L.
1960. Forest wildlife management in Germany. J. Wildl. Manage. 24(2): 147-161.

German hunting is highly formalized and traditional. A hunter must pass a difficult examination, which covers aspects of game and traditions, before he can secure a license. All land, public and private, is included in the revier (or district) system, and the hunter must be invited to hunt by a revier owner. The revier owner is responsible for preparing a shooting plan which includes feeding game and insuring perpetuation of trophy animals through selective cropping. A licensed hunter who belongs to a revier has high status, for he has demonstrated his knowledge of traditional hunting rules and ethical concern. Before animals are shot, they are studied through binoculars to determine whether they meet specific requirements spelled out in the shooting plan. After the game is shot, it becomes the property of the revier owner, and no hunter expects to take home game although he may be given a small portion of meat. Hunter clothing is characterized as formal. Red shirts and a "slouch" hat are considered foolish. Germans wear green clothing, neat trousers, a necktie, and a respectable hat.

KEYWORDS: Management, Germany, landowner-private, characteristics.

937. __________
1968. Public use of forest wildlife: quantity and quality consideration J. For. 66(2): 106-110.

Quantitative games such as "cost-benefit" and "count the people participating" need replacement with an "esthetic game." Public concern for quality has arrived. Regulation of hunting and fishing pressure is an immediate quality consideration. The emphasis should shift from "game" management to "wildlife" management. Today's outdoor recreationists seek not only material but also esthetic, emotional, spiritual, and intellectual challenges.

KEYWORDS: Esthetics, resource use, fishing.

938. Webber, Joel F.
1950. Ancient beliefs about fish. Tex. Game Fish. 8(6): 20-21, 29, illu

Most of our modern superstitions are relics of the ancients. The Egyptians believed the carp was the bravest of all fish and that eating carp flesh increased one's perseverance and good fortune. Successful fishing in the days of the ancients was governed by charms, occultisms, and the position of the planets and the moon. Anglers often regarded unusual fishes they caught as wayward pets of the gods.

KEYWORDS: Historical value, folklore, fishing.

939. __________
1955. Man the hunter. Tex. Game Fish. 13(2): 11-12, 23, illus.

Author describes development of "man the hunter" and "man the sportsman" from prehistoric time to the present. Man's weapons are significant in this development.

KEYWORDS: Historical value, equipment.

940. Weber, Andrew J., Frank B. Barick, and Jerry Wood
1966. Calibration of deer hunting effort and success. 20th Conf. Southeast. Assoc. Game Fish Comm. Proc. 20: 181-188, illus.

A statistical analysis of participation and kills on wildlife management areas in North Carolina during 1965-66 revealed that the average for 13,468 buck hunters was 1.8 trips each and 21 trips per kill. Local buck hunters were most successful, and all hunters were more successful in the morning. Either-sex hunts were made by 8,817 hunters, with an average 1.3 trips each and 15 trips per kill.

KEYWORDS: North Carolina, harvest statistics, either-sex hunt, big game.

941. Weber, Henry M. D.
1963. What kind of outdoor recreation can an exploding population expect? 43d Conf. West. Assoc. State Game Fish Comm. Proc. 43: 52-56.

Author examines points of agreement, difference, and divergence among members of the conservation movement. Issues easily agreed upon include: use of poisons, water pollution, parks and wilderness preservation, abuses to lands, predator "control," and market hunting. Points of divergence include: quantity and quality priorities in granting a license to kill wildlife, failure of State and Federal agencies to protect wildlife, dollar value of wildlife, dangers incident to the influence of pressure groups that benefit from exploitation of wildlife, and dangers of exotic species importation.

KEYWORDS: Non-consumptive use, conservation.

942. Webster, H. T., and Ed Zern
1945. To hell with fishing. 87 p., illus. New York: Appleton-Century-Crofts, Inc.

This book contains a collection of cartoons and humorous short stories about fish and fishermen. Essays include: how to dispose of dead fish, why dumb people catch more trout than smart people, how to tell fish from fishermen, all about guides, all about big-game fishing, and the truth about Izaak Walton.

KEYWORDS: Fishing, non-consumptive use, characteristics, folklore.

943. Westerman, Fred A.
1936. What are public waters? 28th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 28: 95-102.

A brief history is given of the development of definitions for "public" and "private" waters and navigability. A summary is given of the Pine River Case which involved the rights of an Ohio citizen who acquired the title to both banks of several miles of a Michigan trout stream and then attempted to prevent public fishing from the water by jamming the river with logs. The final decision favored the public interest and declared the river to be navigable and public.

KEYWORDS: Michigan, landowner-private, historical value, legislation, resource use.

944. Westerskov, Kaj
1951. Observations on deer kill under different systems of hunting. J. Wildl. Manage. 15(1): 27-32.

In 1945, Denmark's deer harvest doubled that of Michigan. Higher kill under the Old World system was due to closer herd checks, longer season, no

bag limits, and the hunting right invested in landownership. Hunters in Michigan lack the requirement for making a greater kill: a good knowledge of the deer herd--its numbers, age, health conditions, development, and sex ratio.

KEYWORDS: Big game, Michigan, Denmark, harvest statistics.

945. Whisenhunt, Matt H.
1961. Suggested methods and pitfalls of selling an antlerless deer season to the public. 15th Conf. Southeast. Assoc. Game Fish Comm. Proc. 15: 453-455.

A four-step method includes: listing objections and alternate plans after an antlerless season has been suggested, refuting objections with biological data, educating employees on the proposal, and using all news media to disseminate information.

KEYWORDS: Public relations, either-sex hunt, education.

946. White, David L.
1955. How New Hampshire attached the dollar sign to its fish and wildlife. N. H. Fish Game Dep. Tech. Circ. 11, 20 p.

In 1952 a mail questionnaire sample of 3,260 sportsmen was made from six license categories, including resident and non-resident hunting and fishing. Two followups to nonrespondents were made and an interview was attempted for persistent resident nonrespondents. The data show sportsmen spent an average $144.66 during 1952. Residents spent over $11.6 million compared with $10.7 million spent by nonresidents. The highest expenditure for residents was transportation, which accounted for 21 percent of their total expenditure. For nonresidents, food and lodging took 57 percent of their total expenditures. Fourteen different expenditure items are listed.

KEYWORDS: Resident vs. nonresident, New Hampshire, economics.

947. White, William M.
1953. Economic value of fish and wildlife. Va. Wildl. 14(6): 21-23, illus.

Author discusses difficulties in estimating hunter and fishermen expenditures. Sportsmen expenditures of $3 billion for 1950 are based on an estimated sportsmen expenditure of $100 each.

KEYWORDS: Fishing, economics.

948. Whiteman, Eldon Eugene
1965. A comparative study of the effect of a traditional and a specially designed college course in biology upon conservation attitudes. Ph.D. diss., Mich. State Univ., 203 p.

A Likert-type scale was used to test and evaluate conservation attitude changes in two control and one experimental Michigan college biology classes. The experimental class was given 5-week conservation and ecologically-oriented course of renewable resources--soil, water, forests, and wildlife--preceded by an introduction to the population crisis and its effect on the natural resource base. The control classes received no conservation instruction. Results showed a positive change in the attitudes of the experimental group; no statistically significant changes occurred in either control group; sex was not a factor in attitude change; rural students were influenced

more by their place of residence than were urban and suburban students; 4-H training appeared to affect attitudes, but scouting had no significant effect. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: Michigan, conservation, education, preferences.

949. Whitesell, Dale E.
1952. An analysis of the farmer-hunter problem in Ohio. 17th Conf. North Am. Wildl. Trans. 17: 533-538, illus.

Personal interviews were made with a sample of the farm operators living in the open country zone of Ohio. The open country zone consists of all unincorporated places. The survey revealed that 61.8 percent of Ohio's farm land is available to hunters who obtain the farmer's permission, and only 3.9 percent of Ohio's farm land is closed to all hunting. Thirty percent of the State's farm operators have experienced hunter damage, with 66.3 percent of this involving fence damage. Various nuisances (such as shooting near buildings, hunting out of season, road shooting, and neglecting to close fence gates) and the percentage of farmers reporting them are tabulated.

KEYWORDS: Ohio, farmer-sportsman relations.

950. ________
1968. Our most important endangered species--the hunter. Conservationist 22(5): 28-31, 47, illus.

The vice president of Ducks Unlimited encourages wildlife management to save the hunter from extinction, since the hunter contributed $100 million toward wildlife conservation in 1966 and still provides most of the funds necessary to maintain and improve waterfowl habitat.

KEYWORDS: Economics, antihunting.

951. Whitesell, Dale Edward
1951. A comprehensive study of the Wood County, Ohio, township hunting associations. M.S. thesis, Ohio State Univ., 70 p., illus.

Due to a general disregard for the farmer's rights throughout the county prior to 1930, farmers organized into 12 associations during the 1940's. Objectives of 11 of these were studied and found to be as follows: to afford mutual protection to landowners and hunter permittees, to insure an adequate brood stock yearly, and to have association lands used by as many hunters as possible. Personal interviews with 322 farm households showed that association members reported fewer incidents of trespass and and damage than the non-association farmers. Through trial and error one of the associations found that 75 non-resident permittees and 125 landowner permittees were a suitable number of hunters on the 4,000-acre area to insure human safety and protection of game stock. Suggestions for running a farmer association are given.

KEYWORDS: Farmer-sportsman relations, upland game birds, Ohio, harvest statistics.

952. Whiting, Gerry Harshorn
1968. Ice fishing as a form of outdoor recreation in an expanding urban environment: Kensington Metropolitan Park: a case study. M.S. thesis, Univ. Mich., 111 p.

Restricted to University of Michigan campus use.

KEYWORDS: Fishing, preferences.

953. Whittaker, James C., and James F. Connors
1971. The "Maine Sportsman" revisited. Life Sci., spring. 5 p.

Usable questionnaires were received from 583 respondents to an earlier study of Maine sportsmen, which represented a 56-percent response from those contacted. Less than one-third of the respondents were consistent hunting or fishing license purchasers. Nearly all resident hunting license purchasers hunted deer in 1968, and most spent 5 or more days in pursuit of their game. Snowmobile owners may be overrepresented in this survey. Few use their machines to get to deer hunting areas. Almost half the snowmobile-owning respondents reported using their machines to go ice fishing and nearly 41 percent went pleasure cruising on 40 or more occasions during the 1968-69 winter season. The non-resident big game hunter typically makes one trip of a week's duration. The nonresident who participates in both hunting and fishing is likely to make about seven trips of 1 or 2 day's duration each.

KEYWORDS: Big game, fishing, Maine, resident vs. nonresident, characteristics, equipment.

954. Wiita, Clifford B., and James G. Bell
1959. Managed hunting at Horicon. Wis. Conserv. Bull. 24(10): 12-14, illus.

Description is given of regulated hunting for waterfowl, pheasants, and deer at Horicon Marsh. Six-year summary of man-days, pounds of game, and dollar value is given. Overuse suggests need for rationing. (No analysis of data. Also see Bell, Gunther, and Jahn (1956) and Bell, Jahn, and Gunther (1955).)

KEYWORDS: Wisconsin, management, economics, archery, harvest statistics.

955. Wildlife Management Institute
1971a. Report to the Western Association of State Game and Fish Commissioners on nonresident hunting and angling. Wildl. Manage. Inst., 16 p.

Thirteen western States, including Alaska and Hawaii, were examined. There were 268,000 non-resident hunters and 927,000 non-resident anglers in 1970. Non-resident sportsmen were most numerous in Wyoming, Colorado, Idaho, and Montana. On the average, it cost a nonresident 5.5 times as much to hunt as it did a resident, while anglers paid 2.5 times as much. Total hunting revenue from nonresidents ranged from 1.3 percent in California to 84.7 percent in Wyoming, and yet the nonresident comprised only 9 percent of all hunters. Nine recommendations include: (1) non-resident hunters should pay no greater than five times what residents pay for the same privilege, (2) non-resident anglers should pay no more than three times what the resident pays, (3) non-resident quotas on hunters should be established only for wildlife management reasons such as safety or harvest of species, (4) States may prohibit nonresidents from hunting species that are in limited numbers, (5) mandatory use of guides should be eliminated unless there are safety considerations, (6) State wildlife commissions should be authorized to set quotas and controls to accomplish the above recommendations, (7) residence requirements should not be greater than 6 months, (8) States heavily dependent on non-resident income should seek funds from other sources, (9) uniformity and reciprocity of fees among States should be established as a desirable goal. (Seventeen tables.)

KEYWORDS: Economics, administration, fishing, resident vs. nonresident, surveys.

956. __________
1971b. The American game policy and its development 1928-1930. Wildl. Manage. Inst., 44 p., illus.

Article includes the report of the Committee on American Wildlife Policy which was presented to the 16th American Game Conference in 1929 and a summary and formal policy statement presented to the 17th American Game Conference in 1930. This analysis of the American game policy includes precise definition of the following: game management and administration and the mechanisms of management, classes of game and land in relation to management, an analysis of the farm game problem (organizing farmers and sportsmen, criteria of sound landowner relationships, and recent developments), an analysis of the forest and range game problem, the wilderness game problem, the migratory game problem, controversial issues (predator control, excess game, "protection" vs. management, native vs. exotic species), fact finding and education, and finally organization and finance. (See Leopold 1929, 1930a, 1930b for more detailed abstracts.)

KEYWORDS: Historical value, administration, education, farmer-sportsman relations, predator, profession, management.

957. Wildner, James
1948. Public hunting grounds: how set up and why. Wis. Conserv. Bull. 13(10): 7-10, illus.

A summary is made of the Wisconsin public hunting grounds program including administration, area selection, lease and purchase of areas, and public cooperation.

KEYWORDS: Landowner-public, administration, Wisconsin.

958. Wilkins, Bruce Tabor
1967. Outdoor recreation and commercial fishery data development, and use in planning: a case study, Town of Southold. Ph.D. diss., Cornell Univ., 180 p.

Focus was on the development of methods, such as personal interview, useful in estimating levels of participation for swimming, boating, picnicking, fishing, clamming, and hunting. Land and aerial observation yielded figures on participant days; but further study of boating and hunting participation, perhaps using time-lapse camera, is suggested. On-site, personal interviews provided appropriate socioeconomic characteristics. Planning based upon recognition of variations in user characteristics (by residency group or between different group activities) is urged. Suggestions are given to restrict deterioration of recreationally attractive portions of the marine ecosystem. Changes in recreation participation activities are projected. Procedures are given to community planners for quantifying outdoor recreation for amenity or economic purposes. (Condensed from *Dissertation Abstracts*.)

KEYWORDS: New York, fishing, research methods, management, economics.

959. Willard, E. V.
1936. Control of fish, game, lakes and streams in the various States by the Federal Government. 28th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 28: 48-55.

Present Federal laws and regulations, giving jurisdiction over wildlife within federally owned areas, constitute a challenge to exclusive State

control. Divided responsibility does not produce increased efficiency and harmony between State and Federal agencies. State control is favored but it can be lost through negligence. To properly maintain and operate the increasing number of federally owned areas, Federal agencies may be forced to invade a State's jurisdiction and sources of wildlife revenues.

KEYWORDS: Federal-State jurisdiction, legislation.

960. Williams, Fred
1955. Highlights of progress in law enforcement in the last decade. 9th Conf. Southeast. Assoc. Game Fish Comm. Proc. 9: 19-25.

Paper gives a concise outline of law enforcement progress by States in the Southeastern Association of Game and Fish Commissioners. Suggestions are given for advancing enforcement standards.

KEYWORDS: Enforcement, historical value, Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, North Carolina, South Carolina, Tennessee, Virginia.

961. Williams, Frederick Arthur
1960. A plan for improving hunter-farmer relationships based on the Orenco Game Management Project. M.S. thesis, Oreg. State Coll., 66 p.

Thesis describes Oregon Game Department's adaptation of the Pennsylvania Cooperative Farm-Game Program, including details of field-rearing of pheasants Thirty-three landowners signed agreements to allow regulated hunting on their lands, and 21 were interviewed. Only one farmer reported property damage by hunters, while four reported crop damage by birds. Management reports show the average hunter spent 2.55 hours afield and killed 0.53 pheasant. Dog "harassment" tended to disperse birds to adjacent areas. Eleven (50 percent) of the farmers preferred that all hunters ask permission to hunt.

KEYWORDS: Management, Oregon, landowner-private, farmer-sportsman relations.

962. Williams, Lou
1950. The Federal point of view in river basin management; Part I. 40th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 40: 129-135.

A brief outline is given of the history and principal objectives of the Tennessee Valley Authority and a discussion of this agency's contributions to recreation, forestry, soil management, and conservation. The fishing use for Guntersville Dam jumped from 72,800 fishermen catching about 4.6 pounds per trip in 1947 to 166,700 fishermen catching 5.4 pounds per trip in 1949. License sales in Tennessee totaled $560,000 in 1947 compared with $80,000 in 1934.

KEYWORDS: Economics, fishing, historical value, harvest statistics, Federal-State jurisdiction, surveys.

963. Williamson, Leslie A.
1940. Regulated private shooting preserves in Connecticut. 5th Conf. North Am. Wildl. Trans. 5: 354-359.

Since 1934, regulated shooting preserves in Connecticut have not hurt the public interest. Private preserves do not appreciably lessen the hunting pressure. Over a 6-year period, 21,252 birds were not killed. However, many of these may have drifted off the preserves to become available to hunters on public shooting areas.

KEYWORDS: Crowding, refuge, management, Connecticut, upland game birds, plant and shoot.

964. Wilson, John E., and Robert F. Perry
1961. Controlled waterfowl hunting. N. Y. State Conserv. 15(2): 2-5, illus.

The New York Conservation Department's two largest waterfowl areas are managed to provide quality recreation through controlled hunting. On the Wilson Hill Game Management Area during 1960, the permit system was used to provide maximum data on waterfowl kill. The cost of controlled public hunting should be charged directly to the participants. Most hunters were inexperienced, unfamiliar with waterfowl identification, and reluctant to report a crippling loss. The Oak Orchard Management Area has adopted the hunter control plan and also serves as an outdoor laboratory for testing new management techniques. Due to its high cost, controlled hunting is incorporated only on intensively managed wetlands capable of sustaining annual waterfowl populations.

KEYWORDS: Management, New York, user fee, waterfowl.

965. Winch, Captain Frank
1922. Posted property and a solution of the hunting problem. Calif. Fish Game 8: 179-181.

The policies of the Eisner National Rod and Gun Club are outlined: to recognize the farmer's rights as a sportsman and landowner, to assist him in game propagation, to share the burdens and the pleasures of hunting with the farmer, to equalize the number of city sportsmen and farmers in the club's directorate, to secure legislation in the best interest of the majority, and to encourage sportsmanship, safety, and conservation.

KEYWORDS: Resource use, farmer-sportsman relations, clubs.

966. Windsor, B. W., and Walter L. Flory
1967. Cooperation between civilian and military game law enforcement. 21st Conf. Southeast. Assoc. Game Fish Comm. Proc. 21: 558-560.

Article describes the "outstanding" relations between civilian and military game wardens on the Marine Corps base at Quantico, Virginia.

KEYWORDS: Enforcement, Virginia, landowner-public.

967. Winnie, Robert F.
1954. It's a bum gamble. Wis. Conserv. Bull. 19(4): 7-8.

Out-of-staters who try to operate with resident licenses have much to lose.

KEYWORDS: Fishing, law violation.

968. Wirth, Thomas L., and William E. Gerl
1952. Door County sport fishing - 1951. Wis. Conserv. Bull. 17(4): 19-21, illus.

A creel census in Wisconsin during the 1951 season of 1,730 anglers revealed an average of one fish taken for each 46 minutes of fishing.

KEYWORDS: Fishing, harvest statistics, Wisconsin.

969. Wisconsin Conservation Commission
1948. Aldo Leopold. Wis. Conserv. Bull. 13(6): 2-3.

Obituary of Aldo Leopold is presented by Wisconsin Conservation Commission.

KEYWORDS: Historical value, biography, conservation.

970. Wolf, Bill

1956. Hunters never had it so good. Sat. Evening Post 229(17): 38, 39, 115, 116, 120, illus.

The development of a commercial pheasant shooting preserve near Gettysburg, Pennsylvania, shows the problems involved in beginning a preserve. These include finding suitable cover, deciding whether to raise or to buy young pheasants, and overhead costs. The advantages of preserves include longer shooting seasons, close proximity to population centers, higher bag limits, and high success rate per hunter.

KEYWORDS: Pennsylvania, plant and shoot, upland game birds, landowner-private.

971. Wood, Roy

1956. An experiment in regulated pheasant hunting, Allatoona Reservoir project, Georgia. 10th Conf. Southeast. Assoc. Game Fish Comm. Proc. 10: 190-196, illus.

Hunting of 100 released birds on a 120-acre lot was sustained for 4 days, during which 25 hunters exerted a total pressure of 33 man-days. Each of seven hunts averaged 3 hours in duration. Eighty pheasants, or 2.4 birds per man-day, were bagged at a cost of $3.30 per bird, exclusive of ammunition, dogs, transportation, and equipment. Hunting conditions were natural, dog work excellent, shooting reasonable sporting, success satisfactory, and cost average.

KEYWORDS: Upland game birds, harvest statistics, Georgia, economics, plant and shoot.

972. Woodin, William H.

1966. Esthetic values of native animals, p. 73-76. *In* Native plants and animals as resources in arid lands of the Southwestern United States: a symposium. J. Linton Gardner (ed.). Am. Assoc. Advance. Sci. Symp.

Western man's attitude toward animals has been based on their direct usefulness to him. Not until the 18th century did the idea that animals could be valued for their own sake first appear in print. Increasing numbers of people take pleasure in observing wildlife.

KEYWORDS: Esthetics, non-consumptive use, historical value, benefits.

973. Woods, John Parkman

1921. The interfusion of politics and wild life. 13th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 13: 21-37, illus.

Charge is made that political appointment to conservation positions is unfair and unwise.

KEYWORDS: Administration, conservation, politics.

974. Woods, John W., Larry Shanks, and Dale Walker

1969. Florida's fishing future. Fla. Wildl. 23(7): 22-26, illus.

In 1968, 152,000 non-resident and 460,000 resident fishing licenses were sold, contributing $150 million to Florida's economy. Pollution is the greatest threat to the State's fishing resource. Major sources of aquatic degradation are: discharge of domestic, agricultural, and industrial wastes, stabilization and reduction of water levels, increased runoff of

pesticides and nutrients, unrestricted dredging and filling, unauthorized introduction of exotic species of fish, uncontrolled killing of water hyacinths, and failure to fully utilize a natural resource by restricting the removal of commercially harvestable fish. Suggestions are given for sustaining and enhancing water resources and are related directly to the previously listed problems.

KEYWORDS: Fishing, Florida, pollution, economics, resource use.

975. Woodward, Hugh B.
1947. Why public lands should be held for the public. 37th Conf. Int. Assoc. Game Fish Conserv. Comm. Proc. 37: 74-86.

Federal public lands should not be ceded to State or private ownership until permanent guarantees concerning land deterioration and misuse, provision for wildlife use, and provision for public recreation rights are assured.

KEYWORDS: Landowner-private, resource use, conservation, landowner-public.

976. Woolner, Frank
1960. Hunter orange--your shield of safety. Field Stream 65(6): 36-37, 157-160, illus.

Recent tests in Massachusetts have rendered yellow obsolete as a hunter safety color. About 1,267 people were used as subjects; and the following colors were tested: yellow, red and fluorescent blaze orange, fire orange, arc yellow, and neon red, with white as a control. Eight to 9 percent of the men had some form of color-deficient vision. Blaze orange and the other three fluorescents were more rapidly seen and identified than the yellow and red.

KEYWORDS: Safety.

977. Worley, David P., and John D. Gill
1969. Strengthening the wildlife manager's hand in multiple-use conflicts. 26th Conf. Northeast. Wildl. Trans. 26: 11-26, illus.

Methods used by economists to compare alternative courses of action may sharpen the land manager's judgment in identifying and resolving his multiple use conflicts. One needs to recognize the critical factors in management for each resource, to predict the effects of manipulating each factor, and to display the interactions among the various management choices. Display of the interactions on relative scales of benefits allows more positive judgment to be directed toward management goals. This approach to resolving conflicts is illustrated, with examples based on timber, squirrel, turkey, and deer management.

KEYWORDS: Management, resource use, economics, big game, small game, upland game birds.

978. Wright, John
1965. The hunter and the law of trespass in Ontario. Rod Gun 66(12): 20-21, illus.

Trespass in Ontario is considered an interference with possession rather than with title, and the fines are stiff. Owners are protected by the Petty Trespass Act, the Game and Fish Act, or the common law under which the trespasser may be liable although he has caused no damage.

KEYWORDS: Landowner-private, law violation, Canada, legislation, enforcement.

979. Wright, Stillman
1943. Some unregarded factors in creel-census studies. 8th Conf. North Am. Wildl. Trans. 8: 387-392.

Conclusions concerning a Utah fishery where diurnal changes in fish availability are rapid and complete lead to erroneous conclusions when catch per man-hour is used to measure fishing pressure and fish availability. The man-hour is unreliable as a measure of seasonal change because time per fishing trip remains more or less constant, but effective fishing time changes markedly. It is unreliable as a measure of annual change because the mean time per trip changes from year to year, but effective fishing time remains fairly constant. Proposed units of effort are the man-effective-hour for seasonal changes and the man-trip for annual changes.

KEYWORDS: Harvest statistics, fishing, research methods, Utah.

Y

980. Yeatts, E. S.
1968. Significance of law enforcement--Virginia Special Areas. 22d Conf. Southeast. Assoc. Game Fish Comm. Proc. 22: 555-560.

Author discussed special trout areas and related management programs of land acquisition, public education, law enforcement, creel checks, and stocking. Law enforcement officers commend the program to sportsmen while patrolling the areas for violations.

KEYWORDS: Enforcement, fishing, Virginia.

981. Young, Stanley P.
1942a. The war on the wolf; Part 1. Am. For. 48(11): 492-495, 526, illus.

A brief history of man's 2,700-year-old practice of rewarding wolf killers, with particular emphasis on the conflict which has raged across North America in the wake of an expanding livestock industry for more than three centuries.

KEYWORDS: Predator, historical value.

982. ________
1942b. The war on the wolf; Part 2. Am. For. 48(12):552-555, 572-574, illus.

The North American conflict between man and wolf is traced westward over a trail blazed by professional wolf poisoners and enraged stockmen to the last stand of the wolf on the Great Plains.

KEYWORDS: Predator, historical value.

983. ________
1943. Early wildlife Americana. Am. For. 49(8): 387-389, 414, illus.

An historical account is given of the earliest recorded bounty plan for any predator on the Pacific slope of North America. Bounties were designed to curb the puma in Lower California and Mexico.

KEYWORDS: Predator, historical value.

984. ________
1967a. The strychnine caper; Part I. Am. For. 73(6): 20-23, 62-63, illus.

This is part I of an historical account of the use of strychnine poisoning against the coyote and the wolf.

KEYWORDS: Predator, historical value.

985. ________
1967b. The strychnine onslaught; Part II. Am. For. 73(7): 32-33, 52-53, illus.

This is part II of an historical account of the use of strychnine poisoning against the wolf and coyote.

KEYWORDS: Predator, historical value.

986. Yuhas, Joseph G.

1962. A comparison of respondents and non-respondents to a hunter questionnaire. M.S. thesis, Ohio State Univ., 53 p.

Personal interviews with 7.67 percent of 1,773 questionnaire non-respondents (Peterle 1961, 1967) showed that hunters failed to respond because: "I didn't hunt enough, " "lack of time," "questions too personal - didn't pertain to hunting," and "lack of interest." Chi-square tests showed no significant difference between respondents and nonrespondents for marital status, sex, hunting success, and "who took you on first hunt?" But, non-respondents differed from respondents in having greater unemployment, lower income, less education, fewer days hunting, less membership in sportsmen's clubs, less hunting before age 13, fewer born on a farm, different occupational patterns, more hunts with companions, and younger age.

KEYWORDS: Characteristics, research methods.

Z

987. Zeedyk, William D.
1964. Kentucky's Primitive Weapons Hunting Area; its management, administration, public use and acceptance. 18th Conf. Southeast. Assoc. Game Fish Comm. Proc. 18: 120-124.

The 7,300 acres are limited to persons with primitive weapons such as longbows, crossbows, muzzle-loading rifles, and muzzle-loading shotguns. Management objectives include promotion of primitive weapons hunting, emphasis on quality hunting, demonstration of wildlife management techniques, and stimulation of the local rural economy. Policies include keeping regulations to a minimum, emphasizing habitat development, developing and maintaining populations at the maximum sustainable levels, and protecting the remote atmosphere while facilitating optimum harvest. Regulations favoring the primitive weapons hunter over the conventional hunter were avoided. Care was made not to arouse public feeling against the area. There is an indication that the primitive weapons hunters stimulated the local economy. In 1963, 95 deer hunters showed that they had hunted 290 days; 59 used longbows to kill nine deer, three used crossbows to kill two deer, and 33 used muzzle-loaders to kill three deer.

KEYWORDS: Archery, administration, Kentucky, management, harvest statistics.

988. Zeller, Howard D.
1960. Surveys for fisherman access in Georgia. 14th Conf. Southeast. Assoc. Game Fish Comm. Proc. 14: 239-242.

Data from Georgia's public access areas were collected by surveying and classifying all the "big water" in the State. Forms used to classify fisherman access and fishing camps are included. Access surveys should provide the basis for a building program and permit a better distribution on little known or underfinished areas. Good publications on statewide access are valuable to sportsmen and must clearly present information regarding locations, facilities, and travel routes, although this may necessitate a lengthy and expensive publication.

KEYWORDS: Access, fishing, Georgia, research methods.

989. Zern, Ed
1947. How to tell fish from fishermen or a plague on both your houses. 99 p., illus. New York: D. Appleton-Century.

This book contains a collection of cartoons, anecdotes, and humorous short stories about fish and fishermen. Included titles are: the low-down on guides; card shark; sex life of fishermen; shaggy fish story; sex life of fishes; once a fisherman always a barefaced liar; all about women fishermen; how to buy a reel.

KEYWORDS: Non-consumptive use, characteristics, folklore, fishing.

990. ________
1960. I loathe and detest all fish tournaments. Sports Illus. 13(19): 54-55, illus.

Big-prize angling derbies should be ended because: they transform an essentially non-competitive sport into a competitive contest; all the

traditional values associated with fishing become secondary to winning money; tournaments encourage cheating; and the defenders of tournaments are rarely sportsmen or conservationists.

KEYWORDS: Fishing, philosophy.

991. ________
1972. I am a hunter. Audubon 74(1): 17-19.

The author describes a day in a duck blind and defends his hunting activity to nonhunters and antihunters. By visiting the marsh without a gun or without the intention of using it, man becomes a spectator, or a peeping tom, or a bystander. Nature is one big food chain, and man is part of the chain when he acts as a predator-hunter. Antihunters are curiously selective with the "reverence for life" argument when it comes to fishing, logging, and farming. The conservation activities of hunters have saved many species through habitat restoration.

KEYWORDS: Antihunting.

992. Zimmerman, Donald E.
1966. Determination of the sources of conservation information and characteristics of selected Kansas sportsmen. M.S. thesis, Kans. State Univ., 102 p., illus.

Of two Kansas sportsmen's groups, 363 members (68.5 percent) responded to a mail questionnaire and one followup. Responses indicate 88.7 percent watched outdoor conservation television shows, 83 percent read a hunting and fishing or related sporting magazine, 78.6 percent read outdoor columns or pages in newspapers, 63 percent listened to outdoor or conservation radio programs, and 60.6 percent read conservation magazines. Sportsman characteristics are given for age, income, occupation, education, sex, status, membership affiliation, and presence of children.

KEYWORDS: Preferences, characteristics, conservation, non-consumptive use, Kansas, communications.

993. ________
1972. Sources of conservation information. J. Environ. Educ. 4(1): 62-63

Questionnaires were sent to a random sample of 532 Kansas sportsmen and 68.5 percent were returned. Results indicate that television was the most common source of conservation information, followed by sporting magaaines, newspapers, radio programs, and a State fish and game conservation magazine. The attitudes and knowledge of the respondents were reflected in their answers to many questions on management practices. Generally, sportsmen whose names had been obtained from the *Kansas Fish and Game* magazine mailing list were better informed on wildlife management practices than respondents who were sampled from the Kansas Wildlife Federation mailing list.

KEYWORDS: Conservation, communications, preferences, Kansas.

994. Zimmerman, F. R.
1962. Where will you hunt? Wis. Conserv. Bull. 27(5): 8-9, illus.

To provide more room for the hunter, Wisconsin Conservation Commission has purchased thousands of acres within easy reach of cities.

KEYWORDS: Resource use, Wisconsin, farmer-sportsman relations.

995. Zwickel, Fred

1961. Are hunters affecting game character? Wash. State Game Bull. 13(4): 5.

Bulletin presents the following interesting but unsupported concept: easily observed animals are tamer and are thus under heavy hunting pressures. Results are genetic selections favoring wilder, less tame animals. This accounts for hunter complaints of scarce game animals when in fact they have been redistributed. Properly used, hunter selection could be used to produce a more desirable sports animal.

KEYWORDS: Preferences, management.

AUTHOR INDEX[3/]

[3/] *Includes all junior authors.*

KEYWORD INDEX

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USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW

Major Outbreaks of the Douglas-fir Tussock Moth in Oregon and California

Boyd E. Wickman · Richard R. Mason · C. G. Thompson

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE
PORTLAND, OREGON

ABSTRACT

Case histories of five tussock moth outbreaks that occurred in California and Oregon between 1935 and 1965 are discussed. Information is given on the size and duration of the outbreaks, the presence of natural control agents and the damage caused. Most of the outbreaks were eventually treated with DDT. However, enough information was available from untreated portions to show the probable trend of natural events in the absence of direct control. Repeated patterns observed in each of the outbreaks enabled certain generalizations to be made about natural population behavior and tree impact.

All infestations followed a 3-year cycle with inconspicuous to minimal defoliation the first year, severe foliage loss the second year, and ultimate collapse of the population by the end of the third year. The most severe tree damage occurred in the second year. Additional loss of foliage before population collapse in the third year was usually of minor importance in terms of total impact. Although other natural factors were involved, a virus disease appeared to be the principal cause of insect mortality during collapse.

Keywords: Douglas-fir tussock moth, *Hemerocampa pseudotsugata*, population, tree damage, DDT, control.

PREFACE

The Douglas-fir tussock moth is one of the most destructive forest pests in western North America. A very severe infestation is now in progress on some half million acres in the Blue Mountains area of northeast Oregon and southeast Washington. Heavy damage has already occurred, and more is expected in 1973 and perhaps later. Forest managers are much concerned and looking for alternative ways of dealing with the situation.

To assist in this problem, the PNW Station felt it desirable to assemble all available information, both published and unpublished, on histories of previous outbreaks, damage that occurred, insect population trends, and effectiveness of natural and applied controls. Hopefully this information will be helpful in guiding control considerations and strategies for the present outbreak.

CONTENTS

SUMMARY

1. Tussock moth populations can increase in a single year from relatively inconspicuous levels to numbers causing severe defoliation. Detection at low levels is difficult. Most of the outbreaks reviewed were not detected or adequately assessed until visible defoliation had occurred, which was the second year (outbreak phase) of the cycle. Outbreaks can collapse naturally at the end of the second, or most commonly in the third, year (decline phase). To use direct control action most effectively for preventing damage, outbreaks must be detected during the first year of their cycle (release phase) before significant defoliation has occurred.

2. In each of the five outbreaks described, there was no significant spread of defoliation in subsequent years beyond the initial area of infestation. Local outbreaks apparently develop largely from resident populations which build up slowly over several years before entering the outbreak cycle. Although early-instar larvae are easily dispersed by wind, they are not relocated in enough concentration to cause significant damage before the natural collapse of the outbreak.

3. A nuclear polyhedrosis virus appears to be the major mortality factor causing population collapse in most tussock moth outbreaks. In natural virus epizootics, egg masses are usually contaminated by the beginning of the decline phase and disease-caused mortality occurs throughout the larval cycle. However, there is usually continued defoliation of new needles before the population collapses. To prevent this defoliation and possible added tree mortality before population collapse, chemical control has often been applied, but always during the declining population phase. Thus, the actual effectiveness of control applied at that stage of an outbreak can be difficult to demonstrate. For example, limited comparisons in California of two chemically treated with two untreated areas showed no significant differences in total tree mortality.

4. Almost half the total tree mortality occurs in patches coincident to the distribution of high population centers; the remainder is scattered throughout severely defoliated areas. Control treatments should be applied early and selectively to prevent these "hot-spots" of tree mortality.

5. As much as one-third of the stand can be killed in large outbreaks, but aside from the patches of tree mortality, recovery of the other severely defoliated areas can be rapid. Two outbreaks suffering heavy tree mortality 33 and 25 years ago have shown such rapid growth in surviving trees that light, selective cuts have been made recently.

INTRODUCTION

The Douglas-fir tussock moth is a serious pest of fir forests in western North America (Wickman et al. 1971). It defoliates Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, and grand fir, *Abies grandis* (Dougl.) Lindl., in Oregon and white fir, *Abies concolor* (Gord. & Glend.) Lindl., in California and south-central Oregon. Since 1936, six serious infestations have recurred at about 10-year intervals in the two States. The timing of several outbreaks is similar to that reported by Sugden (1957) in British Columbia, but different host types and population behavior are involved. Severe defoliation of California white fir stands has resulted in tree mortality, top-killing, and growth loss (Wickman 1963).

During the course of every major outbreak, land managers ask questions like: "How much tree mortality and other timber damage will occur? When will the populations subside? Will the infestation spread next year? If we do not treat, when will natural agents cause the outbreak to collapse?" Some of these questions have been at least partially answered, and others are in various stages of study and reporting. We believe that a history of the large outbreaks in California and Oregon will be of value by pulling together all published and unpublished information on population trends, natural and applied control, and resulting damage.

Our restriction of covering only California and Oregon outbreaks is based on availability of published information, unpublished file records, and experience of the authors and others. We include only those outbreaks that were large enough to warrant control action or that resulted in the publication of biological data (fig. 1, table 1). This excludes a severe outbreak that occurred over limited areas in eastern Oregon from 1937 to 1939 (Keen 1952). Buckhorn[1/] reported this outbreak detected in 1937 and extending over an area of 6 by 20 miles on Rudio Mountain (between the Malheur and Umatilla National Forests). "Considerable" timber was reportedly killed before the infestation subsided in 1939.

We have also excluded several small, severe outbreaks that were first discovered in the central Sierra Nevada during the summer of 1971 and which declined the same year from unknown causes.

The following records are compiled from published data and file records from the Pacific Southwest Forest and Range Experiment Station, Berkeley, California, and the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, and the authors' personal observations and unpublished data. The outbreaks are discussed chronologically.

1/ *Unpublished typewritten report, "Douglas-fir tussock moth, history and extent of outbreaks," by Walter J. Buckhorn, USDA, Bureau of Entomology and Plant Quarantine, Forest Insect Laboratory, Portland, Oreg. (Undated, probably 1947.)*

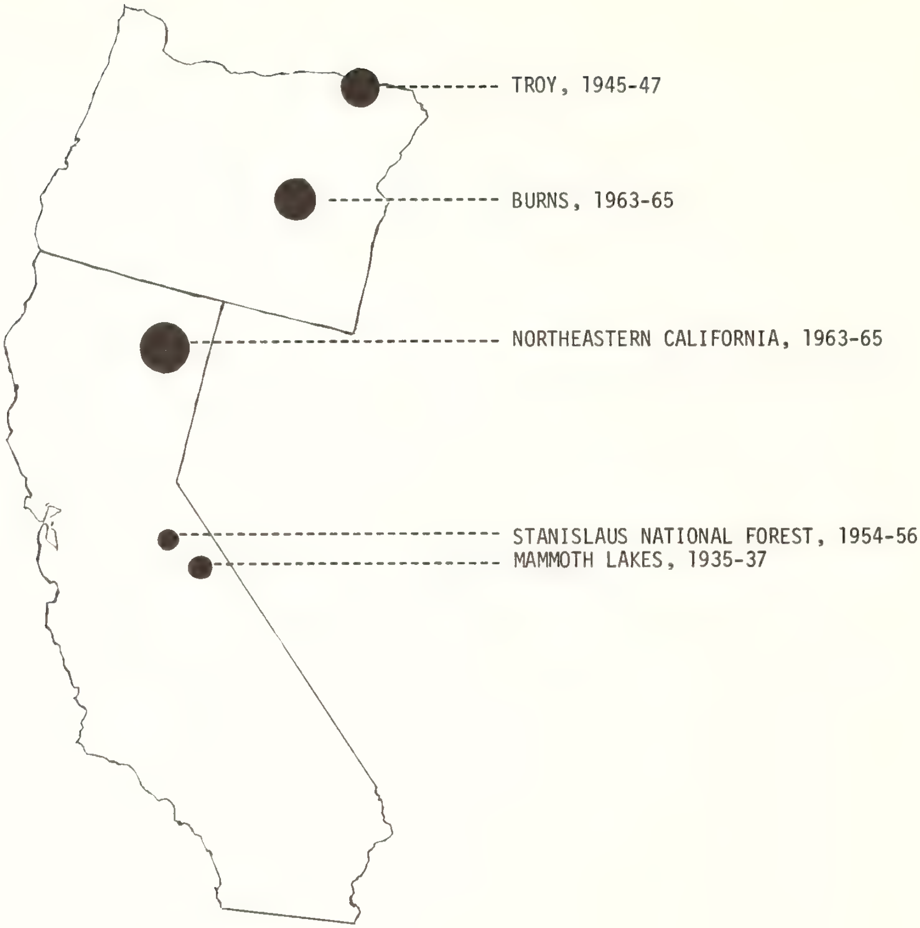

Figure 1.--*Location of 5 major Douglas-fir tussock moth outbreaks in California and Oregon, 1936-65.*

Table 1.--*Statistics of major tussock moth outbreaks in California and Oregon*

Location	Dates	Detection	Major defoliation	Insecticide treatment	Virus discovery	Total infested	Treated
						------*Acres*------	
Mammoth Lakes, Calif.	1935-37	1936	1936	--	1937	15,000	0
Troy, Oreg.	1945-47	1946	1946	1947	1947	56,065	14,000
Stanislaus National Forest, Calif.	1954-56	1954	1955	1956	1955[1/]	10,000	9,560
Northeastern California	1963-65	1963	1964	1965	1964	76,000	57,079
Burns, Oreg.	1963-65	1963	1964	1965	1964	65,945	65,945

[1/] Heavy natural mortality of larvae observed but cause of death not recorded.

OUTBREAK HISTORIES

Mammoth Lakes, California, 1935-37

This outbreak was first reported and visited by entomologists in 1936. In June 1937, J. E. Patterson visited the area and summarized the outbreak situation.[2] Eaton and Struble (1957) have reported this outbreak as occurring from 1931 to 1938, dates obtained from Patterson's handwritten field notes. Where Patterson obtained these dates is a mystery since his official survey report cites the detection date as August 1936 (see footnote 2). This report states that 1935 cocoons were found in 1936 by D. DeLeon. In early June 1937, Patterson reported severe defoliation on six areas comprising a total of 1,930 acres (Patterson subsequently expanded this to 15,000 acres in his field notes). Patterson's notes state that the infestation reached a peak in 1936 and 1937. By late August and September 1937, a "wilt" disease was found on 25 percent of 200 caterpillars examined. The infestation completely subsided in 1938 (Patterson implied that no caterpillars were found in 1938). A natural virus apparently suppressed the population completely within 1 year, and the infestation did not spread beyond the original outbreak areas. Fortunately, Patterson established a 5-acre study plot in the middle of one of the most severely defoliated areas. This plot was checked annually for white fir mortality until 1942, reestablished in 1957, and used for research purposes through 1970. The damage on the plot was summarized by Wickman (1963). Briefly, tree mortality amounted to 29 percent of the white fir green stand volume or 10,596 board feet per acre. Growth reduction occurred during the years 1935-38; however, there was a prolonged drought in the area from 1930 to 1934, so the growth picture is complicated (Wickman 1963). The infestation can also be dated by tracing year of top-kill. An evaluation of decay organisms in top-killed trees at Mammoth Lakes, 33 years after the outbreak, showed that top-killing did not start until 1936 (Wickman and Scharpf 1972). This was most likely the first year of severe defoliation, especially since Patterson's report noted severe defoliation in early June 1937, which would have resulted from 1936 feeding.

This is the only outbreak that can be analyzed for long-term effects of defoliation. A study on the plot area showed that decay defect in trees top-killed 33 years ago was not economically serious (Wickman and Scharpf 1972). Also, 29 percent of the white fir stand was killed on the severely defoliated plot area. However, 33 years later, in 1970, the residual stand on the plot had grown fast enough to support a selective white fir cut of 2,158 board feet per acre (Wickman and Scharpf 1972).

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[2] *Unpublished typewritten report, "Tussock moth,* Hemerocampa oslari: *Preliminary examination of infested areas on the Inyo and Mono National Forests, California, June 23-25, 1937," by J. E. Patterson, USDA, Bureau of Entomology and Plant Quarantine, Forest Insect Laboratory, Berkeley, Calif.*

Troy, Oregon, 1945-47

This outbreak was first detected by entomologists in August 1946. It was estimated that the infestation covered 10,000 to 12,000 acres of grand fir-Douglas-fir forests, and almost complete defoliation had occurred on 500 to 600 acres in patches ranging up to 50 acres.[3/] Local residents indicated that defoliation had begun in some areas in 1945. There was a concurrent and much larger outbreak in Idaho against which control action using DDT aerial spray was being planned. Therefore, a thorough aerial survey was carried out in March 1947 by W. J. Buckhorn. He found, after this survey, that the infested area comprised 56,065 acres west and north of Troy on private lands and the Umatilla National Forest. Severely defoliated patches of timber occurred on 1,265 acres.[4/] Buckhorn mentioned in this second report that there was a possibility that a major portion of the threatened timber might be killed and that the outbreak might expand beyond its existing limits. After a ground check by R. L. Furniss and Buckhorn in April 1947, they predicted that the "prospects are that the outbreak will subside late this season, after most of the feeding is over, or in 1948. Relatively little spread is anticipated beyond the 56,000 acres already infested, in varying degrees. Most of the outlying parts of the area harbor too light an infestation to be a serious threat--at least not in 1947." They recommended treatment of 14,000 acres of forest that was most severely defoliated.[5/] The 14,000 acres near Troy were then included in the Idaho Control Unit and sprayed with 1 pound of DDT in 1 gallon of fuel oil per acre from June 24 to July 2, 1947.

W. J. Buckhorn spent the spring and summer of 1947 studying tussock moth biology and monitoring the spray project on this outbreak. His field notes give the following course of this infestation. By May 28, egg hatch was nearly complete. By June 11, where populations were high, most or all of the new (1947) foliage had been fed upon by larvae in the second and third instar, the larger larvae beginning to feed on older foliage. On June 18, great numbers of larvae of all instars were seen migrating on ground and up and down trees, creating much webbing. "Millions of larvae dead in webbing." Thousands were also falling to the ground at base of trees. The next day, June 19, Buckhorn noted many third-instar larvae falling to the ground at the base of trees. Many

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[3/] *Unpublished typewritten report, "First memorandum on the Douglas-fir tussock moth outbreak near Troy, Oregon," by Walter J. Buckhorn, USDA, Bureau of Entomology and Plant Quarantine, Forest Insect Laboratory, Portland, Oreg., Sept. 23, 1946.*

[4/] *Unpublished typewritten report, "Second memorandum on the Douglas-fir tussock moth outbreak near Troy, Oregon," by Walter J. Buckhorn, USDA, Bureau of Entomology and Plant Quarantine, Forest Insect Laboratory, Portland, Oreg., Apr. 10, 1947.*

[5/] *Unpublished typewritten report, "Third memorandum on the Douglas-fir tussock moth outbreak near Troy, Oregon," by R. L. Furniss and W. J. Buckhorn, USDA, Bureau of Entomology and Plant Quarantine, Forest Insect Laboratory, Portland, Oreg., Apr. 25, 1947.*

sluggish larvae were found in webbing, and piles of dead larvae were found at the base of the majority of mature trees. On June 24, DDT spraying was begun and completed by July 2. By July 17, mature larvae were found and parasitism was noted, presumably on the untreated areas. Parasites were numerous by July 23, and on July 28 many apparently parasitized larvae were seen wandering and dying and pupation was found. On August 6 this entry: "Very little increase in numbers of cocoons. Live larvae are very scarce. Numbers of dead ones have increased considerably. Many at bases of trees, others hanging on trunks or branches. It appears that the infestation (presumably on the unsprayed areas) is disappearing through disease and parasites."

The last entry states: "pupation about complete and little mortality at Mosier Corral" (a lightly defoliated area not visible from the air on the west end of the infestation). There are no reports of increased tree mortality in 1947, and by 1948 natural control factors brought the scattered spots of surviving infestation under control.

There is an additional statement made by Buckhorn in another unpublished report that is worth quoting (see footnote 1).

> On the nearby Wallowa National Forest an infestation was reported on some 1,500 acres near Promise, Oregon, in June of 1947. Some 320 acres of the most heavy infestation were sprayed from the air on July 15, 1947, with a dosage of DDT similar to that applied on the Idaho and Troy areas. Apparently the large larvae were more resistant to the small dosage of DDT (1 lb. per acre) which caused complete mortality of the smaller larvae on the other two projects, as little mortality occurred. A short time later, however, natural factors, disease and parasites, brought about almost complete control. Two other small spots of infestation, 800 and 200 acres respectively, found west of the Promise center, were also wiped out by natural control.

Stanislaus National Forest, California, 1954-56

This outbreak in Calavaras and Tuolumne Counties in the central Sierra Nevada was characterized by a series of seven infestation centers (mostly on ridgetops) totaling 10,000 acres, strung out for 35 miles at about the 5,000-foot level. The infestation was first found by entomologist G. L. Downing in 1954 and was checked by G. C. Trostle on the ground and aerially mapped in the fall of 1955. By this time defoliation was so severe that many white fir trees had lost most of their foliage.[6] Areas around the centers with visible defoliation

[6] *Unpublished mimeographed report, "Douglas-fir tussock moth, Crane Meadows and Thunder Hill areas, Stanislaus National Forest, fall 1955 appraised survey," by G. C. Trostle, USDA Forest Service, California Forest and Range Experiment Station, Berkeley, Calif., Feb. 15, 1956.*

were ground checked and they showed light or no damage. "The lightly defoliated areas could not be discerned from the air." Trostle observed that the infestation first became epidemic in 1953, based on the number of old pupal cases found in 1955. It is not clear how or why 1953 pupal cases were distinguished from 1954 cases unless "1953" is a typographical error and should read "1954." Based on observations of G. L. Downing, defoliation first became noticeable in 1954 in the Stanislaus outbreak. There were some areas further north (Eldorado County) that were defoliated in 1953 but did not become outbreaks. Trostle goes on to say that there were indications the epidemic peaked and had started to decline in 1955. This was based on the difficulty of finding larvae and pupae in some of the infestation centers and discovery of "fairly high" parasitism and numbers of dead larvae, cause of death unknown. However, it was assumed that even if 1956 was the year of heavy brood mortality, "defoliation will be completed before the majority of the larvae die, so tree mortality may occur whether the population declines or not" (see footnote 6).

Additional air and ground surveys were made in the spring of 1956. Three additional small centers were located by this survey. In early May 1956, egg-mass collections were made from areas that could be reached to get some indication of the success of the overwintering population. The egg masses were force reared in the laboratory and an excellent hatch resulted, indicating another season of heavy defoliation could be expected.[7/] However, these larvae were not retained and reared for virus determination, so the incidence of this natural control factor was unknown.

A total area of 9,560 acres was treated from the air with 1 pound of DDT in 1 gallon of fuel oil per acre, on July 31 and August 1-2, 1956. The visible infestation centers on ridgetops were the only areas sprayed. The larvae were three-quarters grown at that time and control was excellent (see footnote 7). The senior author of this publication observed, prior to spraying, that some patches of white fir had been completely stripped of foliage in 1955 and were dying. And the insects were sprayed rather late in their larval development, resulting in the removal of all the new foliage and some older foliage in the heavy population areas.

There were no sampling methods developed for the Douglas-fir tussock moth at that time, so population appraisals were made by looking for evidence of current feeding on selected trees on survey lines. (By today's standards this gives a crude approximation and even results in biased and inaccurate estimation.) No tussock moth egg masses could be found in the fall of 1956, in either the sprayed outbreak centers or the untreated, lightly infested areas between. There were no check areas or larval collections made, so the presence or incidence of natural virus in the population was unknown.

[7/] *Unpublished processed report, "Control of an infestation of the Douglas-fir tussock moth with DDT aerial spray, Calaveras and Tuolumne Counties, California," by R. E. Stevens, USDA, Forest Service, California Forest & Range Experiment Station, Berkeley, Calif., Feb. 1956 (error: should be February 1957).*

Studies of damage caused by the tussock moth were started in July 1956 by establishing permanent plots throughout the infestation. The first year's examination of the plots, in 1957, showed that 21 percent of the trees were killed in the heavily defoliated plots. One-fourth of this mortality was caused by defoliation alone; other defoliated trees were killed by bark beetles (Wickman 1958). These studies of tree damage were continued for 5 years and showed that 20 percent of the merchantable white fir volume, or 11,071 board feet per acre, died in the heavily defoliated outbreak area (composed mostly of virgin timber); another 1,113 board feet per acre was lost owing to radial growth reductions in partly defoliated trees; 12 percent of these trees were top-killed (Wickman 1963). These losses are amazingly similar to those suffered after the Mammoth Lakes outbreak, also occurring in virgin timber.

Northeastern California, 1963-65

This outbreak in Modoc, Lassen, and Plumas Counties covered 76,000 acres in five infestation centers. By late summer 1964, tree mortality was occurring on heavily defoliated areas in the largest recorded outbreak in California (California Forest Pest Control Action Council 1965). Several tussock moth larvae were found in Modoc County in the summer of 1962; by late summer of 1963, egg masses were found in an area scheduled for treatment to control white fir sawfly. In August 1964, defoliation was visible on thousands of acres and there were patches of completely defoliated white fir scattered throughout the outbreak. Forest Service entomologists spent much of the summer and fall of 1964 evaluating the outbreak. Cocoons and egg masses were sampled during a thorough and intensive cooperative survey.[8/] The populations on each outbreak center were evaluated separately and the tussock moth evaluation report made recommendations for each area. For the largest area--Knox Mountain, 59,730 acres--it was predicted that if the outbreak was not halted, damage would increase and probably spread the following year to all the fir type in the Knox Mountain area (see footnote 8). Consequently plans were made to use DDT to control the Douglas-fir tussock moth during the summer of 1965.

In June and July 1965, 57,079 acres in two of the largest outbreak centers were aerially sprayed with three-quarters of a pound of DDT in 1 gallon of fuel oil per acre.[9/] [10/] The first posttreatment evaluation report stated (see footnote 9):

8/ *Unpublished mimeographed report, "Douglas-fir tussock moth infestations in northern California--1964," by John R. Pierce. USDA, Forest Service, Region 5, Division of Timber Management, San Francisco, Calif., Dec. 14, 1964.*

9/ *Unpublished mimeographed report, "Preliminary report of the results of the Douglas-fir tussock moth control projects, California, 1965." USDA, Forest Service, Region 5, Division of Timber Management, San Francisco, Calif., July 21, 1965.*

10/ *Unpublished processed report, "The Douglas-fir tussock moth in California, a cooperative control project." USDA, Forest Service, Region 5, Division of Timber Management, San Francisco, Calif., Mar. 1966.*

> Data from mortality sampling points throughout the sprayed areas indicates that over 99 percent of the tussock moths are dead in the treated areas. In addition to mortality counts made at established mortality sampling points, beating samples taken at numerous other points have failed to detect any tussock moth populations except very scattered individual larvae which survived the spray. These survivors probably are late hatching stragglers which emerged from the egg after the effectiveness of the DDT had diminished and are so few in number as to pose no threat of continued damage in treated areas.

A later, more comprehensive report of the control operation was issued (see footnote 10). This report gave the results of larval mortality determinations made on groups of caged larvae that were treated and on those that were not treated with DDT. Mortality of treated larvae 10 days after spraying averaged 99.6 percent and untreated larvae, 45.1 percent. Cause of death for untreated larval mortality was not stated, but there was a significant virus incidence in the area where the larval mortality determinations were made.

A natural virus was widely distributed in the outbreaks, and all of the untreated populations suffered heavy larval mortality and were completely suppressed by the end of 1965 (Dahlsten and Thomas 1969). In October 1965, egg mass surveys were made of all outbreak areas and no new egg masses were found in either the treated or untreated outbreaks (see footnote 10).

The nontreatment of several areas offered one of the few opportunities to study the biology and natural course of a tussock moth outbreak and damage in treated and untreated areas. Consequently, several studies were carried out for the next several years. Reliable sampling techniques were developed for various stages of the Douglas-fir tussock moth for the first time (Luck and Dahlsten 1967, Mason 1969, 1970); parasites were determined (Dahlsten et al. 1970); the presence and identity of virus were confirmed (Dahlsten and Thomas 1969); the natural collapse of an outbreak was recorded (Mason and Thompson 1971); feeding behavior was recorded (Mason and Baxter 1970); and an aerial photography technique was developed to sample tree mortality (Wert and Wickman 1968, 1970). These studies resulted in the first comprehensive understanding of Douglas-fir tussock moth outbreaks, collapse, and damage.

Larvae did a considerable amount of feeding the year virus suppressed the population. Larvae on an untreated area removed all new foliage and some older foliage before being killed by virus. Larvae also removed much of the new foliage on treated areas before they were sprayed. Visual estimates of individual tree defoliation on a treated plot area (Stowe Reservoir) with a comparable untreated plot area (Roney Flat), both before (May) and after (August) treatment in 1965, showed the following. Defoliation increased on 51 percent of the 107 sample trees on the untreated plot. Only 12 lightly defoliated trees changed to a heavy defoliation class. The other trees with increased defoliation

were all in the heavy class in May, and they lost an additional 5 to 25 percent of their remaining foliage by August. None of the trees showed foliage gains during the summer. Defoliation increased on 11 percent of the 105 trees on the treated plot, but 40 trees showed improvement with increased foliage growth by August. Spraying with DDT apparently did save foliage. However, tree mortality (measured in 1966 on a series of 0.2-acre plots) was essentially the same on both areas--27 percent of the trees on the untreated Roney Flat and 25 percent of the trees at Stowe Reservoir (Wert and Wickman 1968). By 1967, Stowe Reservoir suffered 32-percent tree mortality; there was no comparable measure at Roney Flat.

There was no spread of visible defoliation from those areas untreated in 1965. A small, new center was found 40 miles northwest of Stowe Reservoir in late 1965, but populations declined without spread in 1966 (Mason and Thompson 1971).

Tree damage was intensively investigated at the 450-acre Stowe Reservoir outbreak center during studies with aerial photography. The second-growth white fir stand suffered 2,518 board feet per acre tree mortality (25 percent of the stand), and 19 percent of the surviving trees were top-killed (Wert and Wickman 1970). An assessment was made of the distribution of tree mortality because the Douglas-fir tussock moth has typically killed trees in patches up to 50 acres in size. A sample of five patches of dead trees showed that an average of 84 percent of the trees was killed in these patches; this type of damage was concentrated on 14 percent of the area and contained 40 percent of the total tree mortality in the Stowe Reservoir outbreak.[11/]

Burns, Oregon, 1963-65

In 1963, tussock moth defoliation was recorded on 15 acres in mixed and pure stands of Douglas-fir and white fir on Antelope Mountain in the Malheur National Forest. By the end of the summer in 1964, defoliation, as ascertained from aerial surveys, covered 39,000 acres on the Malheur and an additional 1,000 acres on the Ochoco National Forest. Ground surveys for eggs in the fall of 1964 increased the total infestation acreage in both forests to almost 56,000 acres.[12/] Defoliation during 1964 was heavy in most of the outbreak areas on the Malheur but relatively light on the Ochoco.

By the end of 1964, it was estimated that the tussock moth had killed immature timber on 1,050 acres and 2.6 million board feet of mature timber. Losses at that time were valued at $219,000. Perkins and Dolph (1967) reported that an additional 33,700 acres of young trees and 262.5 million board feet of

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11/ Unpublished data of B. E. Wickman, 1970 field studies on file, USDA, Forest Service, Pacific Northwest Forest & Range Experiment Station, Forestry Sciences Laboratory, Corvallis, Oreg.

12/ Unpublished report, "Entomological evaluation of the Douglas-fir tussock moth in eastern Oregon, 1964," by D. McComb. USDA, Forest Service, Region 6, Portland, Oreg., 1965.

mature timber were threatened in 1965. These estimates presumably were for the already infested acreages. They further estimated that 122,000 acres of immature timber and 950 million board feet of mature timber would be ultimately threatened, apparently by spread into uninfested areas, "unless control was achieved in 1965."

For ease of description and evaluation the infestation was partitioned into five natural geographic areas: Antelope Mountain, King Mountain, Gold Hill, and Vance Creek on the Malheur National Forest and Silver Springs (Snow Mountain) on the Ochoco National Forest. Natural virus disease was detected in 1964 larval populations at Antelope and King Mountains and at Gold Hill (see footnote 10). Subsequently, virus was also found in 30 percent of the fall egg masses.[13/]

However, in the fall of 1964, new egg masses outnumbered the old in all areas except Gold Hill. On Antelope Mountain, the new to old egg mass ratio was 14 to 1. The consensus among foresters and entomologists late in 1964 was that the tussock moth population was increasing and that natural control factors were insufficient to stop the epidemic before serious damage occurred. They felt that large tussock moth populations would be present in all infestation areas the next spring and that more tree killing was imminent unless effective control measures were taken.

During the period of June 10 to July 1, 1965, a total of 65,945 acres were sprayed with DDT for control of early-instar larvae (Perkins and Dolph 1967). Application was by helicopter and at the rate of 0.75 pound DDT in 1 gallon of fuel oil formulation per acre. Because of public concern at this time about side effects of DDT in the environment, impact of the spray on other resources, including fish, water, soil, forage, and cattle, was evaluated by scientists working independently of the project (Crouch and Perkins 1968, Tarrant et al. 1972). In addition, a small test was made of two other candidate insecticides, Dursban, an organic phosphate, and Zectran, a carbamate.[14/]

Effectiveness of the control project was determined by comparing pre- and post-spray larval counts and new 1965 egg masses to the number of 1964 egg masses. Larval mortality averaged 98 percent, and no new egg masses were found in any of the fall surveys. The spray project was "considered highly successful with virtually complete mortality of the target insect" (Perkins and Dolph 1967).

13/ *Personal data of C. G. Thompson, Principal Insect Pathologist, USDA, Forest Service, Pacific Northwest Forest & Range Experiment Station, Forestry Sciences Laboratory, Corvallis, Oreg.*

14/ *Unpublished report, "Dursban and Zectran pilot control study for Douglas-fir tussock moth," by D. McComb. USDA, Forest Service, Region 6, Portland, Oreg., 1966.*

The tests of Dursban and Zectran proved significant, not because of their affect on the tussock moth, which was generally unsatisfactory, but because of the series of methodical observations made in the test area after treatment (see footnote 14). Study plots for observing larval mortality were established in each of the two spray-treatment areas and in an unsprayed control area. The test was conducted on July 8, 1965, when larvae were mostly in the third instar. Evaluations were made by counts of larvae 1 day before spraying and 1, 3, and 10 days after spraying. These counts showed that, although there was a reduction of larvae on the sprayed plots 1 day after spraying, a considerable number of larvae were unaffected by the insecticides. However, within a few days, larvae on all plots began to succumb to disease. In his report of the test, McComb described this incident as follows: "Sometime between the third and tenth day after spraying, larval mortality from a polyhedral virus disease began to occur throughout the study area. Therefore, all the moth population reduction occurring during this period cannot be attributed to the insecticides." In reference to egg ratio surveys made in October after the test, McComb stated further that they "were of no value in measuring effectiveness of the insecticide as the virus disease had wiped out the entire larval population in the study area prior to pupation. On the transect lines, 2,062 old egg masses were collected without a single new egg mass being found."

Aerial spraying of DDT obviously brought about an abrupt termination of larval feeding in early summer. It is also clear that the outbreak was simultaneously declining from disease and that it collapsed completely by fall from natural causes.

OUTBREAK PATTERNS

It is important to maintain an historical perspective of biological events. Such events are not always easy to interpret; but if a pattern develops during the recurrence of events, an examination of that pattern helps us understand what is happening and, through association, gives us some ability to predict the outcome of events in the future.

We feel that the careful examination of five Douglas-fir tussock moth outbreaks over the last 36 years in California and Oregon has shown some consistent patterns. A brief discussion of population buildup, decline, and tree damage resulting from defoliation describes these patterns.

Population Behavior

To understand tussock moth outbreaks we must first know something about how populations change. Enough empirical information from past outbreaks is now available to make fairly good predictions about expected population change. Without going into the mathematics or biology of change, we can simply observe patterns that have occurred time and again to gain insight for prediction.

Outbreaks of forest defoliators can be viewed as going through three phases of population change: release, outbreak, and decline (Greenbank 1963). With some defoliators, each phase may cover several years. In outbreak cycles of the Douglas-fir tussock moth, all phases seem to be compressed into about 3 years (fig. 2). That is, 1 year for release, 1 to 1-1/2 years of outbreak, and 1/2 to 1 year for decline. In the release phase, defoliating larval populations may multiply five to 10 times or more and, thus, increase from a relatively insignificant level to one of outbreak proportions in a single year. Several years of inconspicuous buildup are probably required to reach the level where quick release can occur. The second year, or the outbreak phase, is the period of most conspicuous tussock moth defoliation. This, of course, is the year when the "blow up" is usually first recognized. Some outbreaks apparently collapse naturally at the end of this second year, but frequently a large number of eggs laid that fall indicates a further population increase the next year. However, the third season of the cycle inevitably spells a population decline, especially at high outbreak levels. If defoliation has been severe and egg masses are abundant, survival during the early larval instars is apt to be low. Trees may be defoliated of new needles again in the third year, but the population usually begins to collapse during the summer. Significant oviposition rarely occurs the third year.

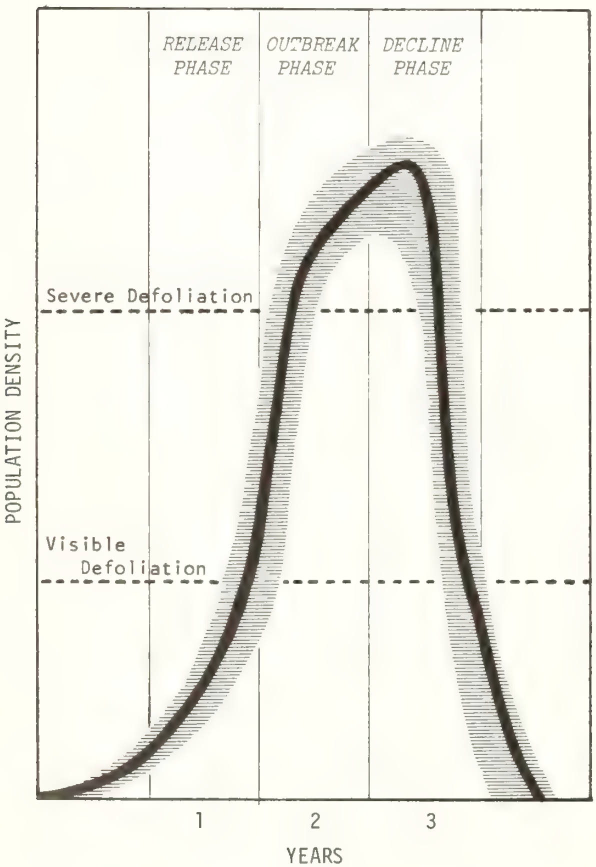

Figure 2. --*Hypothetical model of an outbreak cycle of the Douglas-fir tussock moth.*

Considerable speculation and rhetoric through the years have centered on spread of tussock moth outbreaks. During the Troy outbreak, a Ranger was quoted as saying "the moths were traveling toward a large stand of virgin timber but it was believed the threat had been eliminated (by DDT)."[15/] Justification of large spray programs has frequently been based on the assumption that outbreaks will spread extensively beyond a population center or "hot-spot" unless controlled. This, of course, assumes that outbreaks are often the result of spread from some point of origin rather than the natural buildup of a resident population. Historically, there is no sound evidence to indicate that tussock moth outbreaks ever expand much beyond the boundaries of the initial infestation. The female moth is wingless; thus, oviposition almost always occurs at the site of pupation. Spread must be by early-instar larvae which are easily wing-borne and perhaps can be carried many miles. Although small larvae undoubtedly can be easily dispersed from population centers and may enrich the gene pool of other populations, they apparently do not invade new habitats in the concentrations required to cause significant first-year defoliation. As described in table 1, most outbreaks suffer an overall collapse within 3 years of their inception, so there is little chance for dispersed larvae to build to outbreak levels.

We have found[16/] that tussock moth outbreaks develop after a buildup of populations that have been resident in the habitat for at least several years. Similar results have also been shown for other forest defoliators, which usually exist not as discrete colonies but as individuals scattered in various concentrations over an area (Graham 1963). Tussock moth buildup apparently occurs simultaneously throughout the suitable forest habitats in the area, so that populations of most centers are chronologically within a year or two of each other in terms of abundance. The most favorable habitats for population growth probably reach the release phase first and suffer the most severe defoliation during the outbreak phase. In large outbreaks there may be considerable mixing of larvae so that separate population centers coalesce and end up behaving as a single population. This apparently explains why all populations in a large outbreak, regardless of their abundance level, collapse the same year.

Virus Epizootiology

A nuclear polyhedrosis virus appears to be the major factor in the dramatic population collapse that characteristically terminates major tussock moth outbreaks. The virus does not appear to be a significant factor in endemic population fluctuations nor in sporadic flare-ups of endemic populations. The controlling factor in these endemics is usually a complex of parasitic insects, although other biological and environmental factors may also be involved. The virus spreads so explosively, in high population densities of the tussock moth, that

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[15/] *From a news item in the* Oregon Journal, *July 18, 1947.*

[16/] *Unpublished data of R. R. Mason on file at USDA, Forest Service, Pacific Northwest Forest & Range Experiment Station, Forestry Sciences Laboratory, Corvallis, Oreg.*

it tends to preclude any possible control by entomophagous insects. If the virus were not present in such situations, it is probable that other control factors would soon take over, although perhaps somewhat later than the virus would have. Even in major outbreaks, the virus can only rarely be detected before populations causing heavy defoliation have developed. Nuclear polyhedrosis epizootics have been studied in Washington, Idaho, Oregon, California, and Arizona. Although two distinct strains of the virus have been found which have a tendency toward geographical separation, the course of polyhedrosis epizootics has been the same throughout the West (Hughes and Addison 1970).

Typically, the virus incidence is so low that we have not been able to detect it in the release phase of an outbreak. The disease sometimes, but not always, becomes evident during the later instars during the outbreak phase. If the virus disease is found in phase two, its occurrence is usually spotty and may require intensive surveys to determine its distribution. The decline phase of a tussock moth outbreak has always begun with a virus contamination of the egg masses. The source of this egg contamination is puzzling, since it has occurred in populations which in the previous year were apparently free of the virus as well as in populations with a high virus incidence. The virus present on the overwintering eggs produces mortality which almost always occurs at the end of the first larval instar. Usually this first-instar virus incidence is relatively low--even among larvae hatching from contaminated egg masses. Virus-contaminated egg masses are found throughout the infested area at the beginning of the decline phase, although the incidence is usually highest in the areas suffering the heaviest defoliation the previous year.

Although the source of egg mass contamination has not yet been satisfactorily explained, the course of the epizootic following egg hatch can be explained by the contagious nature of the disease. The initially infected larvae dying in the first instar contaminate foliage which is fed upon by some of the surviving healthy larvae, which in turn become infected, die, and contaminate more foliage. The larvae which die in the early instars are very inconspicuous and usually escape detection by the casual observer. The larvae dying in the last instar, on the other hand, are quite conspicuous. This has lead to a general misconception that the polyhedrosis virus only kills last-instar larvae. Actually, in most of the epizootics studied, the majority of the tussock moth larvae died in the earlier instars (Mason and Thompson 1971).

The speed at which an epizootic develops apparently depends on two major factors: (1) the initial rate of egg mass virus contamination and subsequent first-instar mortality and (2) the density of the tussock moth population. The higher these two factors, the faster the epizootic develops. Our experience has been that if 10 percent of a defoliation-level population is infected in the first instar, the population will be essentially eliminated the same year although a few individuals may survive to pupation. Initial polyhedrosis incidence of 1 to 10 percent resulted in a population collapse the same year; but defoliation may have been greater, and, in one observed case, a small inconsequential population survived until the following year. If 50 percent of the population is initially infected, population collapse may be expected by the third or fourth instar.

Tree Damage

As previously mentioned, most of the defoliation occurs in the outbreak phase (the year of discovery, in most cases), and most of the tree mortality can be associated with that defoliation. Tree mortality is heavy the year after severe defoliation and continues for an additional year after the collapse of the populations (fig. 3). Most of the mortality the second year is aided by bark beetles which are associated with about three-quarters of the total merchantable volume killed (Wickman 1958).

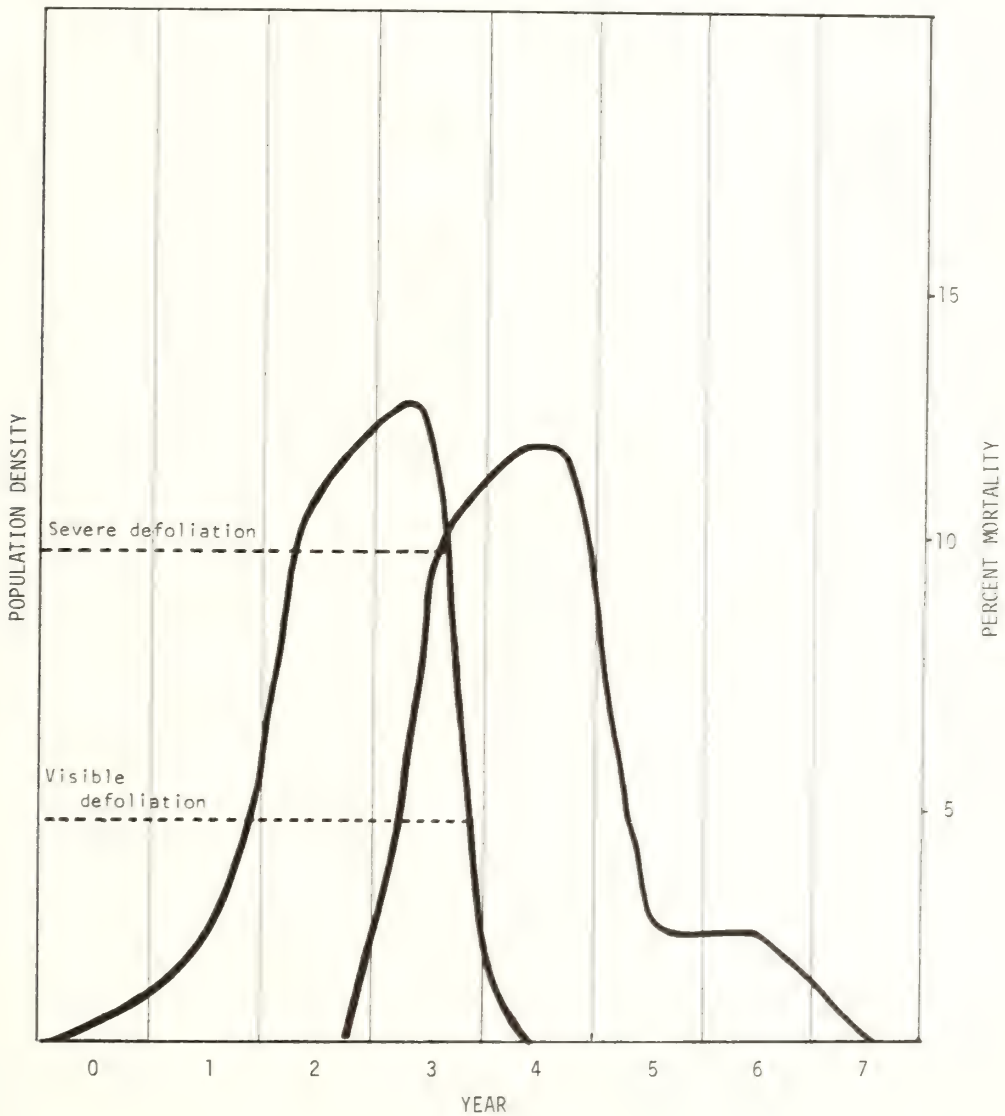

Figure 3.--*Percent tree mortality through a hypothetical Douglas-fir tussock moth outbreak cycle.*

Defoliation occurring the year of decline may be very conspicuous but does not seem to influence the course of events started by the first year of

severe defoliation. For instance, feeding by larvae during the year of population collapse can be severe enough to remove all current foliage and many older needles. In one study area where populations were declining due to virus, 51 percent of the sample trees had additional defoliation before the larvae disappeared. However, this occurred primarily on trees already 75 to 90 percent defoliated. This resulted in additional defoliation on trees that were highly susceptible to death anyway and could be why similar tree mortality losses have been measured on both treated and untreated areas (e. g., Stowe Reservoir and Roney Flat, Stanislaus National Forest and Mammoth Lakes).

As would be expected, the heaviest tree mortality occurs in patches coincident to the distribution of high population centers. These patches of killed trees amounted to almost half the total mortality in an outbreak area. If the patch mortality is left standing, it may create a fire hazard for as long as a decade. Salvage of dead trees must usually be done within a year to recover wood values. And after logging, a clearcut remains. If natural regeneration is difficult to obtain, planting may be necessary with its added costs. Treatment applied early enough to prevent these "hot-spots" of tree mortality should be the primary objective in control considerations.

Aside from the patches of tree mortality, recovery of moderately to severely defoliated stands can be rapid. For example, the 5-acre plot at Mammoth Lakes lost 29 percent of the green stand volume yet supported a light, selective, white fir cut 33 years later because of increased growth on surviving trees. The 1947 Troy outbreak area is being selectively cut at this time, indicating growth recovery in that stand as well.

In lightly defoliated areas, tree damage in the form of growth loss has ranged from 31-percent reduction to an almost undetectable amount. These areas apparently recover completely within a few years after the outbreak.

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NOTE: Registrations of pesticides are under constant review by the Federal Environmental Protection Agency. Use only pesticides that bear the EPA registration number and carry directions for use.

SUMMARY

As a result of an increasing population, our reduced acreage of forest land will be called upon to produce maximum amounts of wood fiber, to satisfy an ever-increasing demand for recreational use, and to produce maximum amounts of clean, pure water. Under such demands, forestry must be practiced with an intensity that is beyond our ability to conceive at present. Of necessity, every tool, including chemicals, must be used in this intensive management for the good of mankind. To achieve these aims, it will be also necessary that we quickly acquire a detailed and intimate knowledge concerning the interactions that occur within forest ecosystems--not only natural interactions among plants, but also those that occur when we artificially induce changes in structure or composition in communities or ecosystems by artificial means. Such changes may not only affect vegetation; they may also affect atmospheric, wildlife, and microbiological conditions as well.

Chemicals are useful, necessary tools for helping to meet needs for food, wood fiber, and water, while man readjusts his numbers and modes of life to the rapidly dwindling resources of the earth. The more selective, less persistent chemicals will continue to play an important role in forest resource management, probably for several decades. However, chemical use must eventually be minimized, for it is simply a system of treating symptoms of unhealthy ecological conditions created by nature or man in the past.

Technological, environmental, and socioeconomic factors will add new dimensions to chemical use, placing greater demands on the research and development process.

Our pressing need, aside from solutions to problems of population pressures and extravagance in natural resource use, is rapid development of the ecological knowledge necessary to manage and maintain a healthy biosphere with minimum use of chemical tools.

KEYWORDS: Chemical control (pests), forest management, pesticides.

INTRODUCTION

We live in a chemical-oriented society. The chemical industry, one of the largest single segments of the world economy, continuously presents us with new materials intended to improve some aspect of human existence. These contributions are viewed as technological advances by some people; others view them as instruments of impending doom. In the moderate view, it is clear that new advances in chemistry are helping support our increasing world population, but some products may have unforeseen adverse effects on humans or their environment.

Although the use of chemicals in forest management goes back a century or more, large-scale use of these materials is a comparatively recent development. Much of the impetus for employing chemicals as silvicultural and pesticidal tools resulted from the availability and effectiveness of materials such as DDT and the phenoxy herbicides whose development was spurred by World War II. Although these new materials were developed with other uses in mind, many proved helpful in controlling insects and unwanted vegetation on forest lands. For the first time, materials that were highly effective against target organisms, relatively inexpensive, and compatible with aerial application methods were available to treat large areas of relatively inaccessible forest lands.

These new materials, especially pest control chemicals, were quickly adopted by forest managers responsible for increasing productivity of forest lands to meet rapidly increasing demands for timber and other forest resources. From 1946 to 1960, use of pesticidal chemicals in forests expanded greatly. However, even at its height in 1960, the total use of pesticides in forest applications was never more than a small fraction of the total use of such materials worldwide. Hall (1962) noted that during the period of greatest insecticide use in the United States, less than 0.03 percent of our 630 million acres of forest lands was treated in an average year; that 95 percent of our forest lands were never treated with an insecticide; and that the average application rate on treated land was less than 1 pound per acre.

Since 1960, concern for the environment has intensified greatly. One effect of this concern, with its attendant controversy, has been to greatly reduce the use of chemicals in forestry. Some chemicals have been banned by law. Others have been withheld from use pending further evaluation of their effects on nontarget organisms and food chains. Others, under development, have been set aside until society and governments determine the future role of silvicultural chemicals.

It is important that the future role of chemicals in forestry be clarified and that criteria be established for assessing their need, effectiveness, and safety. These criteria and related determinations must be based on factual data. Limitations in our knowledge must be clearly spelled out, so that more specific research can be directed to obtain the necessary information.

FOREST PEST CONTROL

Protection against destructive pests is necessary in forest resource management. The cumulative, damaging effects of insects, diseases, and animals seriously limit the productivity, usefulness, and value of forests. In many ways, these pests disrupt management planning and operations throughout the lifespan of a tree crop. In both ecological and economic terms, they represent a component that must be fully understood and controlled in order to obtain optimum outputs and benefits from the forest resource.

Pesticides have long been a primary means of defense against forest insects. They have played a less important role in preventing damage by microorganisms and animals.

Since World War II, significant changes have occurred in the kind and complexity of chemicals used, in equipment and techniques of application, and in general strategies and patterns of use. There has been a phenomenal increase in the number of pesticidal compounds synthesized by commercial manufacturers. These have varied greatly in their chemical and physical properties and in their biocidal capabilities. Until recently, emphasis has been given to compounds that were toxic to and potentially useful against a wide spectrum of target pests. New and sophisticated airborne and ground equipment has been developed for applying pesticide formulations, and new techniques of treatment have evolved. Aerial application of insecticidal sprays to forest areas, for example, now involves aircraft formations, turning patterns, and navigational systems derived directly from military operations. These technological improvements have been an important factor in advancing the use of chemicals against forest pests.

Socioeconomic factors also have had a considerable influence. A worldwide increase in demands for timber products and increased values placed on forests for watershed protection, wildlife habitat, and recreational use have resulted in intensified forest resource management and attention to protection against destructive pests. These new considerations in forest management will probably have a greater effect in determining the future role of pesticidal chemicals in forestry than will the purely technological developments.

Universal concern about the environmental safety of pesticidal chemicals is now having profound effects on the types of chemicals allowed and the manner in which they may be used. This concern involves both their hazards to man and other nontarget organisms in the environment and dangers inherent in processing and handling the materials. Many governments have initiated legislation to regulate pesticide use, and additional statutes are under consideration. Severe restrictions have been imposed on the use of some materials, especially DDT and other chlorinated hydrocarbon insecticides. Some restrictions are categorical, most are provisional. Greatly expanded efforts are being made by a number of agencies in the United States to better evaluate the safety of major pesticides now in use and to develop improved standards for evaluating new chemicals. Other countries are also attempting to establish sound scientific criteria for evaluating the environmental safety of pesticidal chemicals. In the United States, mechanisms have been established for public involvement in the review and decisionmaking processes.

Governmental actions, guided by public opinion as well as technical considerations, undoubtedly will increase in scope and intensity. Research and operational use of pesticides will be affected accordingly.

We can anticipate that the present trend toward more selective, less persistent chemicals will continue. In the United States, DDT has not been used by the Forest Service in forest insect suppression projects since 1967. Use of other broad-spectrum, long-term toxicants has also been reduced. Moreover, we can expect more emphasis to be given to techniques and strategies that will minimize the need for repeated treatments. This will reduce the chances of unexpected and adverse changes in the balance and structure of forest ecosystems.

Research on alternatives to toxic chemicals for pest control has increased significantly during the past 20 years, and results are beginning to appear. For insect control, much attention has focused on attractants, repellents, and feeding deterrents. Attractant compounds include chemicals produced by the insects themselves (pheromones) and host-produced chemicals. The primary attractants of more than 20 major forest insects have been identified, and means of synthesizing them have been developed. Most insect repellents and feeding deterrents are synthetic chemicals discovered through routine screening or trial-and-error testing programs. Large-scale field experiments are underway in the United States and Canada with attractants of the gypsy moth, spruce budworm, western pine beetle, mountain pine beetle, and southern pine beetle to determine what formulations, trapping techniques, release times, and deployment patterns are most effective.

Experiments are also being conducted with repellent and feeding deterrent compounds. The prime objective with these materials is to provide tree protection, not insect control *per se*.

Since these behavioral chemicals are pesticides in the legal sense (in the United States at least), they are subject to the same requirements of safety evaluation for registration as conventional toxic insecticides. Because they are limited to only one target pest and may be required for operational use only sporadically, commercial manufacturers have little or no interest in them. The entire research and development task, including safety testing, must be borne by governmental agencies or universities. The nature of these materials, the many variables affecting their operational use, and the need to evaluate environmental and human safety require a greatly expanded research effort and increased funding and organizational support. In general, the development of more selective, safe, and biologically efficient pesticidal chemicals will require broader participation by public agencies and corresponding increases in expenditures for research and education (Brady 1972).

Another factor that will affect the future of pesticidal chemicals in forestry is the emerging concept of integrated control or, more broadly, pest management. Reliance on chemical treatments as the sole, or primary, means of protection is hardly defensible today. Chemical control of destructive forest pests will be increasingly considered, planned, and conducted as part of a comprehensive, long-term management plan in which pesticide treatments are only one of a number of options available to the forest resource manager. Chemical treatments undoubtedly will have continued high priority, however, in protecting trees

in special-use areas such as nurseries and seed orchards.

To make forest pest management practicable and acceptable, clearly cut thresholds for action must be established. Decisions--especially with chemicals--should not be arbitrary or capricious. The criteria for decisionmaking must be understood by the governmental regulatory agencies concerned, by the public, and especially by the forest resource manager himself. The kind, extent, and degree of impact that is acceptable will depend on the pest involved, its effect on the forest stand, and the resource values at stake. Ecological and socioeconomic factors relevant to each case must be identified, analyzed, and thoroughly evaluated. For every destructive insect, disease, or animal, then, there will be many thresholds for action depending upon circumstances. Above all, we can be sure that the social, economic, and legal pressures for sound, defensible decisions on pesticidal chemical use will increase in the future.

FOREST VEGETATION CONTROL

Herbicides and other vegetation control chemicals have assumed an important role in forestry throughout the world. We have derived great benefits from the use of chemicals in culture of forests, rangelands, and croplands. On forest lands, we have increased the growth of desirable tree species by releasing them from competition of undesirable vegetation; through reclamation and reforestation, hundreds of thousands of acres of formerly nonproductive lands are now producing young vigorous forests; and large areas are producing tree species more useful to man than the scrub trees and shrubs that formerly occupied those sites.

Development of the phenoxy herbicides 30 years ago provided foresters with an effective and economical way to modify structure and composition of plant communities. Today, chemicals for vegetation control include well over 100 herbicides, silvicides, growth regulators, growth inhibitors, desiccants, soil fumigants, and soil sterilants. In 1967, at least 30 major companies in North America, Europe, and Japan were producing such compounds (Day 1967). In addition, about a dozen new biologically active compounds become available each year--far more than can be adequately tested and introduced with proper techniques for safe use. Until the past few years, the expanding literature indicated that this rate of growth might continue. Then, increasing costs and more stringent regulation took their toll. The chemical pesticide industry is increasingly discouraged with prospects for the future; some have closed their plants and others have curtailed research and development (Hollis 1972). Despite this, we continue to seek more selective, more effective, less expensive, and less persistent herbicides for specific problems.

During the same period, our ever-increasing population, the industrial expansion required to satisfy its needs, and our increasingly complex technology have had dangerously adverse effects on our biosphere. Throughout the world, people are becoming more and more concerned about deterioration of our environment and are quickly antagonized by any public or industrial activity that may have such adverse effects.

Herbicides, with their very obvious effects on forests and woodlands, receive

an ever-increasing share of this public antagonism. Despite this hostility, research, experience, and use of vegetation control chemicals on forest lands are increasing and must continue to do so for at least the next few decades. Our rapidly expanding population and the concomitant need for more intensive silviculture will require that we use such chemicals--although with increasing caution--in the future.

Smith (1970) estimated that roughly one-third of the world's land surface is occupied by forests. It seems clear, however, that forests of the future will be reduced in area and that many areas will be reserved for limited use rather than full production of all forest products. This problem is already evident in demands by special interest groups that more and more acreage be set aside for special uses, zoned for housing, reserved for recreation, etc. It seems very clear that foresters of the future will be faced with much reduced acreages of forest land that must be managed most intensively, with the utmost care, and with ever-increasing scrutiny by the public.

Throughout the world, we have a wide variety of forest types ranging from needle-leafed boreal species in the cooler habitats to broad-leafed species that dominate in tropical climates. Such forests may occupy sites for hundreds of years, but they are not static. Whenever a forest is removed or destroyed, a pattern of vegetational change occurs on the site. In the course of this process, many species that were present in earlier stages disappear. But this is all a part of the natural process of succession. When foresters use herbicides, they are simply controlling the natural process of succession. We may reduce the length of time that earlier, less productive seral stages occupy a site and insure an earlier dominance by forest species more useful to man. Or we may retard succession and maintain dominance of a seral forest type that is more productive of wood, water, or recreation desired by man.

The future role of vegetation control chemicals in forest and other land management seems adequately insured in attaining and maintaining these conditions. Chemicals must of necessity be used to reduce competition of undesirable species and increase growth of those more useful to man. Chemicals must also be used to speed succession and insure regeneration of cutover areas. They will be used to improve the composition of our forests, to improve wood quality, and to control rates of growth. Diameter growth will be controlled to provide wood with desired qualities. But silvicides will probably be used less in the future as more of the finer materials are macerated and used as wood fiber.

In the relatively near future, herbicides and desiccants will probably be used to prepare sites for reforestation and to convert chapparal areas to grasslands for a greater production of protein, but their role will also decline. To a more limited extent, desiccants and herbicides may also be used to remove foliage of deciduous species when lives of these trees or plants are threatened by continued transpiration during extensive periods of drought--an extension of what occurs normally in many species in arid areas.

Vegetation control chemicals will probably be increasingly used in improvement of roadsides and recreation areas by selective removal of ugly or undesirable species, while favoring more esthetically desirable plants. Growth inhibitors will be used to control height of plants

along roadways for better visibility and before lookout points for better viewing of scenic areas by the public without the ugly scars that accompany cutting of vegetation.

In the future, forests will probably be visited and used much more frequently by the public than they are now. And having passed through the period of excessive depletion, despoilation, and the traumatic adjustments needed to bring mankind into equilibrium with his biosphere, foresters will be faced with a better educated and more aware public. Although now subjected to public pressures and demonstrations, foresters of the future will be under even greater pressure and must be much better educated to justify the silvicultural practices that they deem necessary. The more intensive use of forest areas and the increased awareness of their importance to mankind will cause the public to question any activity that appears to threaten the forest resource.

Although the future of chemicals in silviculture seems assured, we must increase our study of the ecological effects of these chemicals. Further, we must drastically increase our studies of all interactions within forest ecosystems for an even more important purpose. Man must learn that--although he can live with and slightly modify nature--he cannot overcome long-term natural processes.

OTHER FOREST CHEMICAL USES

In regard to chemical forest management tools other than pesticides, we are perhaps now in much the same situation as we were about a quarter-century ago with pesticides--new chemicals are being offered and used to accomplish management objectives. With the exception of fertilizers and fire retardants, these chemicals are being used in relatively small amounts, just as chemical pesticides were used only a few years ago. However, research will continue to develop new tools with which to accomplish forest land management jobs effectively and economically over wide areas of inaccessible territory where aerial application of chemicals is the only feasible approach. And, doubtless, we will use them. However, we are now well aware that determination of efficacy of new chemicals must be complemented by assurance of their safety.

In terms of present and potential volume of all forest chemical use, fertilizer ranks first. Intensification of forest cultural practices aimed at producing more wood from less forest land must include the use of supplemental plant food. Forest fertilization is now practiced in many parts of the world, and much research is underway to extend the practice. Results of many studies indicate trees and range plants may respond significantly to fertilizer, but that response varies greatly between different sites.

When fertilizer is carefully broadcast on forested lands, the nutrient balance of the ecosystem is changed, but little environmental damage appears possible. Charges that forest fertilizing is harmful to water quality appear to be unfounded (Norris and Moore 1971, Cole and Gessel 1965, Cooper 1969).

With an increasing demand for wood products and a decreasing forest land base, it is highly probable that fertilizer use on forest lands will increase greatly. As a renewable resource, wood fiber certainly will continue to occupy a leading

and increasing role in world industry. Intensification of management must include the use of chemical fertilizer in many situations.

Forest fire retardants rank next to fertilizer in volume of use. In 1970, more than 13 million gallons of fire retardant chemicals were aerially applied to wildfires in the United States. About one-fourth of the retardant solution is composed of chemicals, most of which is diammonium phosphate or ammonium sulfate, both used widely as fertilizers and not in themselves considered to be toxic to higher organisms (Sauchelli 1964, Bell et al. 1968).

There is ample evidence upon which to predict increasing use of chemical fire retardants. In 1969 alone, wildfires burned over 2.7 million hectares of forest and associated rangeland in the United States. Such fires often cause serious damage to the forest environment, both in terms of direct economic loss and from the standpoint of scenic and other esthetic values.

Chemical retardants are used to reduce the environmental damage from wildfire. Further research and product development will undoubtedly result in retardants that are effective and safe. We predict increased use of such materials in the future.

Additional new chemical tools may be offered for use in intensive forestry. A few examples of such chemicals and their uses include alkylpolyoxyethylene ethanol as a soil wetting agent to reduce erosion (Krammes and Osborn 1969); hexadecanol, a saturated fatty alcohol, for use as a transpiration retardant on planting stock (Stoeckeler 1966), on forest stands (Waggoner and Hewlett 1965), and to reduce soil water loss (Gardner 1969); asphalt and wax emulsions as agents for speeding slash disposal by fire (Schimke and Murphy 1966); and tyrosine, a free-amino acid, as a possible stimulator of tree growth and frost resistance (Gagnon 1964). Soil fumigants may also be used to eliminate undesirable pathogens such as *Poria weirii* from the soil and forest floor before planting or seeding areas where such organisms were prevalent before harvest.

Seed production may also be favored by new chemicals that become available in the future, producing not only more but better and more viable seeds. And although our view may be somewhat limited by a lack of experience, we believe that colchicine and similar genetic-modifying chemicals may prove less useful than thought at present. Considering the great number of natural hybrids produced by nature each year for the past hundreds of thousands of years, this chemical approach does not seem too promising.

We can also expect a growing introduction of chemical substances into the forest environment in connection with efforts to raise the permanent road system to higher standards (Tarrant 1967). Bituminous materials for surfacing, dust abatement chemicals, sodium or calcium chloride to reduce icing, and resins or asphalt emulsions for roadbed stabilization all are in use now.

An interesting development of which foresters must be aware is that of potential introduction into the forest environment of exotic chemicals not specifically aimed at land management goals. Two examples should suffice to illustrate this point.

Forest soils, in general, have superior water-absorbing capabilities and can serve excellently as receptacles for

the assimilation and utilization of fluid wastes, including urban sewage (Evans 1970). In the United States, requests are now reaching the Forest Service for sewage disposal sites on forest and range lands. The demand for sewage disposal-recycling sites on "wild" land is expected to increase. Such lands are often available at low cost, potential health hazards and esthetic objections are usually less serious than for lands near populous centers, and forest and range cropping practices permit long, uninterrupted irrigation schedules. Development of large-scale sewage disposal on forest lands is, indeed, a growing possibility and could be a major source of chemical input into the forest environment.

Attempts to manipulate precipitation frequently include the release of chemicals such as silver iodide and zinc sulfite into the atmosphere. In at least one current attempt to alter precipitation patterns, concern over the ultimate fate of chemicals used in weather modification has led to monitoring of plants, soils, and water to determine presence, amount, and distribution of such chemicals and their impact on organisms of the forest environment (Cooper and Jolly 1970).

We could continue indefinitely to list chemicals and their present and potential use. But the real point is that we are constantly presented with chemical materials that promise to achieve intensive forest management objectives in a new, efficient manner. The question is not whether chemicals have a role in forestry during the next few decades, but what uses will be made of them and how these will affect forest management.

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CHOOSING Forest Residues Management ALTERNATIVES

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SUMMARY

Forest residues include logging, road construction, and silvicultural slash or debris and all living or dead woody fiber which may be unwanted because of management problems in the forest ecosystem.

Residues must be managed with forest resources. Management involves disposal, modification, or utilization for wood products. The costs and benefits of the several alternatives available to forest managers must be evaluated in relation to land management goals and constraints. The need for a decisionmaking framework for this purpose is demonstrated by problems and opportunities categorized in four areas: (1) unused wood fiber, (2) conflagrations, (3) impairment of forest resources, and (4) opposition to treatment of residues.

Whether much of the wood fiber left on timber sale areas is truly not usable depends on many economic factors, including direct costs of delivery to a processor and the local supply of similar wood. Public concern over environmental pollution or resource depletion from processing competing nonrenewable resources may, in time, radically increase wood demand, but this is uncertain.

If residues are to be removed and used, incentives must be identified and provided to timber buyers. Buyers and sellers both will benefit if sellers will make residues available at a reduced stumpage charge and thus write off a portion of yarding costs for inclusion in subsequent cleanup. Buyers need assurances of reliable supplies of wood and predictable prices. Processing feasibility studies made by landowners themselves could help with development of such assurances.

Advance modification of fuels or installation of fuelbreaks on strategic locations may be the best residue management for fire control, but probable loss must be weighed against cost. Examples of impairment of forest resources by residues include obstruction to access, esthetic deterioration, and decreased water quality. Objections to residue treatment originate in concerns ranging from the need to meet air-quality standards to the potential for depletion of plant nutrient reservoirs.

To encompass the spectrum of considerations necessary for choosing the best residue treatment, a simple framework is proposed--essentially a formalization of systematic thought processes used by forest managers. This framework provides for comparisons between anticipated consequences of residue treatment alternatives and established land management goals; it will make possible a dialog with a concerned public.

The proposed framework will use quantitative data on costs, benefits, and probabilities, but the opportunity exists to use qualitative data until research results become available. Current research and development related to residues include a recently published conflagration control guide (Dell 1972) and a review of the state-of-knowledge on the biological and physical effects of residues and residue treatments. Other data will result from studies in progress and from a simulation model for determining the feasibility of residue utilization for specific areas.

Keywords: Wood residues, forest management.

INTRODUCTION

Choosing an optimal alternative for forest residue management involves more than merely pursuing an acceptable method of solid waste disposal, or setting a level of expenditures for logging slash disposal, or determining how much wood fiber utilization is feasible. Management of most forest properties, particularly public forests, is increasingly based on the concept of multiple use. Multiple use means balancing the output of several major goods and services: wood, water, recreation, wildlife, and forage. Accumulations of woody residues in the forest can cause protection problems and will frequently interfere with efficient use or enjoyment of the forest. It is apparent that residue management must become part of the overall scheme of forest management.

The purpose of this paper is to suggest a framework for making residue management choices compatible with the often multiple forest management goals established for a given forest area. In order to develop the framework, we have defined forest residues more broadly than is commonly encountered:

> Forest residues include logging, construction, and silvicultural slash or debris, and all living or dead woody fiber which can pose management problems because these may be detrimental to the forest ecosystem as used by man.

This definition permits a systematic appraisal of man-caused slash along with litter and other woody fiber as potential sources of management problems concerned with unused space, undesirable vegetative competition, and conflagrations. Including woody fiber other than logging debris can coordinate residue management opportunities for a forest property as a whole, rather than by piecemeal considerations of the several, separate management functions which may reduce or accelerate rates of residue accumulation.

In the discussion which follows, we will progress to the framework by citing examples of management problems, and of opportunities for solutions, grouped in four problem areas. Although the examples were drawn mainly from the coniferous forests of the Western United States, they are intended to illustrate the universal need for a framework. With it, forest managers anywhere should be better able to make decisions, and at the same time, bring better perspective to the concerns of the forest-using public for esthetics, water quality, wildlife, and related values. The problem areas are: unused wood fiber, conflagrations, impairment of other forest resources, and opposition to treatment of forest residues.

The problem of unused wood fiber warrants detailed discussion because it is within the timber harvesting activity that both the general public and foresters have concentrated efforts to solve residue problems. Further, forest management frequently is initiated through timber harvesting. This emphasis does not imply, however, that this category ranks higher than the other three.

UNUSED WOOD FIBER

When wood fiber remains unused following logging in the Western United States, a conservation issue develops. Special interest groups concerned with preservation of forest areas for parks and wilderness question the need to devote vast public forest areas to timber production.

Harvesting of old-growth timber in much of Western United States yields large volumes of residues which, though heavily defective and rotten, do contain sound, unused wood fiber. Surveys indicate that 50 to 90 percent of the total residue volume on some clearcut units in the Douglas-fir type is potentially usable under existing technology, but various size and quality classes of residues are difficult to separate for efficient processing. With the many economic factors that influence timber processing costs and returns, generalized statements seldom really identify which forest residues are truly waste.

One significant factor that influences residue utilization is the demand for wood products. According to Hair and Fleischer (1970), available data on timber demand and supply indicate that, in the next few years, sizable price increases will be necessary to bring the United States' timber demand into balance with supply. Price increases are likely to be especially large for softwood lumber and plywood. Fisher (1971) concluded that stumpage prices will rise steeply during the next 5 years and stressed that increases will substantially exceed those projected for other sectors of the Nation's economy.

Part of the predicted increase in demand for wood could be met and price pressures eased by increased utilization; that is, reducing the volume of wood residues, reusing paper and wood products, and extending supplies through increased efficiency in construction and manufacturing. It is noteworthy that during the past two decades, coarse wood manufacturing residues have been increasingly utilized throughout the United States, and there has been some increase in the use of sawdust and other fine manufacturing residues as well as logging residues.

There is a growing public concern over pollution and depletion costs associated with competing nonwood materials. Restrictions on processing of petrochemicals and metals that would raise costs and force prices up would substantially increase the demand for wood. Yet another possibility is in the use of forest residues to replace fossil fuels and hydroelectric installations for power generation.

In contrast to optimistic projections of demand for wood products, the industry must offset a general rise in materials-handling labor costs for all primary forest products, and by this, may improve on means to handle residues. Materials-handling, as used here, refers to logging activities concerned with moving logs and smaller wood sections from stump to processing plant or place of sale. It includes sorting and bucking logs to upgrade value or to increase usable quantity, as well as including some preliminary processing. As smaller and more defective pieces are taken, higher per-unit handling costs result. To offset higher costs, greater efficiency is needed.

Efficiency in logging is achieved in part through an ever-changing technology involving both equipment manufacturers and users who desire to perform an operation in less time, or with reduced costs. Advances usually result in fewer men being required for a given task, or less time

being required per unit of output. In either case, unit labor cost is reduced but is generally in part replaced by investment in equipment.

For steep terrain, high-lead yarding and other systems with standing skylines are costly to set up because of elaborate guying required. Mobile "jammers" and "skidders," on the other hand, have generally required a more closely spaced road system than high-lead yarders. Both are being replaced with a new generation of even more mobile yarders that require few back-guys and use a cable system consisting of a three-line running skyline automatically interlocked to maintain uniform tension. When used on clearcut areas, a grapple that can be opened and closed by the yarder operator holds the logs, rather than wire-rope chokers which must be set by additional crewmembers. Characteristics of this new generation of yarders are lighter weight, mobility and line speed, and capacity to reach distances of 2,000 to 2,700 feet (600 to 825 meters). Prototypes are being tested. Even with greater mobility and more rapid in-haul capability, loggers will still be faced with the need to amortize substantial equipment investments through high productivity.

These and other developments will tend to lower the direct per-unit costs of materials-handling. With more efficient logging systems, the opportunity to use residues can be improved. However, public pressure to reduce the visual impact of logging is expected to, in part, counteract gains made in logging efficiency. Pressure to reduce "visual pollution" caused by road cuts and fills will likely require longer yarding distances calling for at least some helicopter or balloon yarding systems. Pressure to forgo clearcutting may tend to favor additional shelterwood cutting or other partial timber removal.

With such a variety of interacting forces, it is a temptation to anticipate the invention of miraculous wood products which will create vast markets for low-quality wood. Although development of new products continues, radical changes seldom occur. Manufacturers of products that utilize low-quality wood do so because of cost, not from preference. Substantial progress in the utilization of mill residues for specialty products has been made, and literature on the subject is voluminous; but industrial research and development organizations probably will continue to concentrate on mill and plant residues, deferring attention to residues in the forest. To wood manufacturing firms, this approach is logical; costs have already been incurred in delivery of material to a plant and in partially processing it.

Some apparent guidelines for the land manager seeking residue reduction through increased use of wood fiber are:

1. Progress in utilization resulting from increased timber demand, improved materials-handling, and new product development is likely to be incremental and most influenced by shrinking timber supplies relative to demand for wood products and by prices of wood products relative to those of competing materials.

2. A dramatic change in timber demand requiring residue utilization might, in time, come from public reaction to environmental pollution resulting from processing of such competing materials as aluminum, steel, and plastics; but changes in public policy to conserve exhaustible materials and favor the use of renewable wood fiber are highly uncertain.

3. For residues to be removed and utilized at an accelerated rate in a given locality, incentives must be provided for the logger and processor.

These conclusions suggest that implementation of materials-handling and new product opportunities will be determined by industry innovation, and possibly by governmental demonstrations, on an area-by-area basis.

Sellers of timber must balance the profits on stumpage with those on subsequent investments required to establish a new stand of trees. Particularly for large public ownerships, the efficiency of wood-fiber utilization, in contrast to disposal of logging debris by burning, should be promoted. Both utilization of residues and disposal are intended to accomplish the same results--site preparation for planting and a more acceptable appearance--but utilization frequently can be done with smaller direct and social costs.

At present on public lands, timber selling and subsequent residue disposal are usually administered as two separate activities. There is resistance on the part of timber managers to subsidize purchasers through offering low-quality wood at less than appraised value. The forest protection activity then has a larger task of slash disposal or extra fire protection requiring greater expenditures than if a portion of the residues had been removed.

Any sale of timber stumpage with residue reduction required by the purchaser affects revenues and costs of both parties (fig. 1). As disposal requirements are made more stringent, the buyer will offer less for all the stumpage. The seller may reduce his disposal costs but in doing so forgoes maximum obtainable revenue from timber. In either case, then, generally the seller must expect to bear the cost of residue disposal.

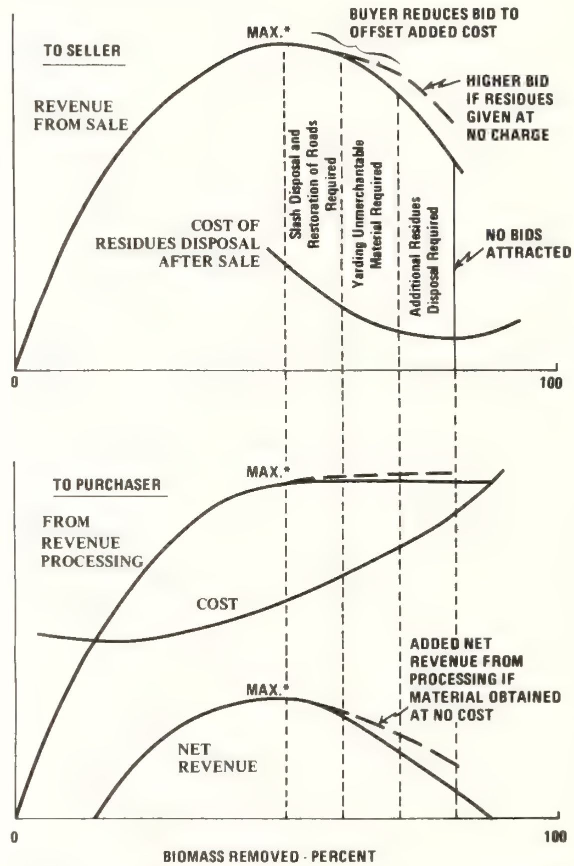

Figure 1.—Revenue and cost to timber seller and purchaser when residue reduction is required in the sale contract.

OTHER PROBLEM AREAS

Other problem areas, although of equal importance, are reviewed only briefly because they are more straightforward than the economic variables that influence timber revenues. Although research and development are definitely needed, opportunities for solutions are generally more apparent in these areas.

DANGER OF CONFLAGRATIONS

Almost every year a critical fire situation occurs somewhere in the western United States forests. The magnitude of damage and suppression costs is staggering. Within a few days in 1970, wildfires in central Washington State burned over 125,000 acres (50,000 hectares) of public and private forest lands. Suppression costs alone exceeded $20 million.

Under dry, windy, and warm conditions, "natural" forest fuels permit spread of fires. When slash accumulations are superimposed on these natural fuels, fire intensity and difficulty of control are severely aggravated. Therefore, aside from esthetics, slash disposal is necessary whenever heavy concentrations of slash retain twigs and needles for several years (Fahnestock 1960). In timber types and stand sizes that can accommodate prescribed underburning, the practice may prove to be the most efficient residue management measure.

IMPAIRMENT OF FOREST RESOURCES

Other forest resources to be considered include water, esthetics, livestock forage, and recreation. The presence or arrangement of forest residues can detract from the enjoyment or satisfaction of users of any of these resources. Typical situations resulting from forest residues are described below.

The Northwestern Region of the U. S. Federal Water Pollution Control Administration (1970) cited logging wastes in Douglas-fir forests as a serious threat to the quality of water yield from cutover timberland. Water quality is adversely affected by chemical pollution caused by leaching of ashes from burned slash, by changes in stream channels clogged with debris, and by increases in biochemical oxygen demand resulting from logging residues submerged in streams.

The forest-using public resents esthetic degradation following timber cutting. Increasingly, forest managers are confronted by groups which oppose all timber harvesting operations, at least in part, because of the logging slash. Vivid, often emotional, descriptions of harvested areas reflect the attitude of these forest users, who are not oriented to timber production. These people, whether informed or not, will have a political impact on the creation and treatment of logging residues.

Livestock ranchers who secure public lands for forage under permit have complained that large logs and other debris in timber stands interfere with the use of the area by domestic livestock. Hunters find it difficult to travel on foot.

Accumulations of residues on Douglas-fir clearcuts, weighing as much as 200 tons per acre (454,000 kilograms per hectare), impede timber management activities such as restocking with young trees. Lesser amounts of residues created by selective cutting or overstory removal can interfere with future silvicultural operations. Dense brushy vegetation frequently encroaches on cutover sites and requires treatment in order to return land to timber production.

When the forest manager is faced with decisions involving two or more resources, maximum output of one product or service may be sacrificed to enhance another. Short-term degradation of appearance resulting from timber cutting may be necessary to develop vigorous new trees which will provide long-term improvement in esthetic quality. Although often obvious to forest managers, these trade-offs are not widely understood. Each situation can vary widely in cause and effect. For this reason, benefits and undesirable consequences have seldom been well quantified. Even when documented, their usefulness for residue management decisions is limited, unless the interaction of residues with all resources present on an area is known.

OPPOSITION TO TREATMENT OF FOREST RESIDUES

To meet the needs of the decision-maker, the effects of forest residue treatments must be quantified. Treatment methods can have environmental consequences far removed from the forest, and the full impacts of these consequences are not always well known.

The most commonly used disposal method for residues is burning. On clearcut areas, slash may be piled or windrowed and burned, but the usual practice is to broadcast burn the entire area. If not performed under favorable conditions of wind, temperature, and moisture content of fuel, large amounts of smoke are carried into the air. If the smoke plume meets a stable layer of air, smoke may accumulate and remain trapped until a change in weather occurs. This is a particularly troublesome phenomenon when smoke fills a heavily populated valley. Public opposition to burning forest residues has mounted because of these air quality considerations. Fortunately, foresters in cooperation with meteorologists are learning how much burning can be done under given atmospheric conditions for the airsheds in which they are working. Global implications and the actual health hazards associated with burning forest debris are less well known. One might conclude from Hall's (1972) review of literature and application of knowledge of the chemistry of combustion, that emotion plays a large role in the expressed concern over wood smoke in the atmosphere. Even so, foresters are asking that wood smoke from various species and species combinations be analyzed to document actual emission products and to relate this knowledge to known health hazards.

Other aspects of the use of fire for the reduction of residues draw opposition. Some silviculturists concerned about the characteristically low levels of available nitrogen in forests suggest that burning contributes to nitrogen deficiency to a degree that is not offset by the benefits of fire hazard reduction and the additional amounts of nutrients rapidly made available for plant use. At least one tree disease may be a result of burning residues. *Rhizina* root-rot was identified as the cause of mortality in Douglas-fir plantations on burned forest sites in British Columbia (Ginns 1968). Surveys in western Washington State have detected the presence of this pathogen, but its distribution and importance remain to be established.

Questions have been raised as to the long-term impact of wood utilization on site productivity. Objections to mechanically chipping or crushing logging residues and mixing them with soil may be based upon an assumed additional nitrogen demand. Both burning and crushing call for examination in terms of the natural recycling of plant nutrients and

of trade-off values.

In sales of public timber, the logging industry objects to extensive cleanup requirements in the sale contract. One practice gaining increasing use requires the purchaser to yard unmerchantable material above a stated size to "landings" and other locations on the sale area. Resulting piles are burned after conclusion of the sale, when smoke dispersal is favorable. Although a cost allowance for such yarding is included in the appraisal of timber to be sold, loggers believe it is often inadequate for the effort demanded. Further, it decreases their production. The degree of cleanup required in remote areas has also been questioned.

FRAMEWORK FOR OPTIMAL RESIDUE TREATMENT

A model of the framework proposed for structuring decisionmaking is basically straightforward (fig. 2). It essentially portrays the thought processes employed by a manager in reaching a decision. The model can be extended to accommodate complex subroutines to evaluate residue reduction alternatives.

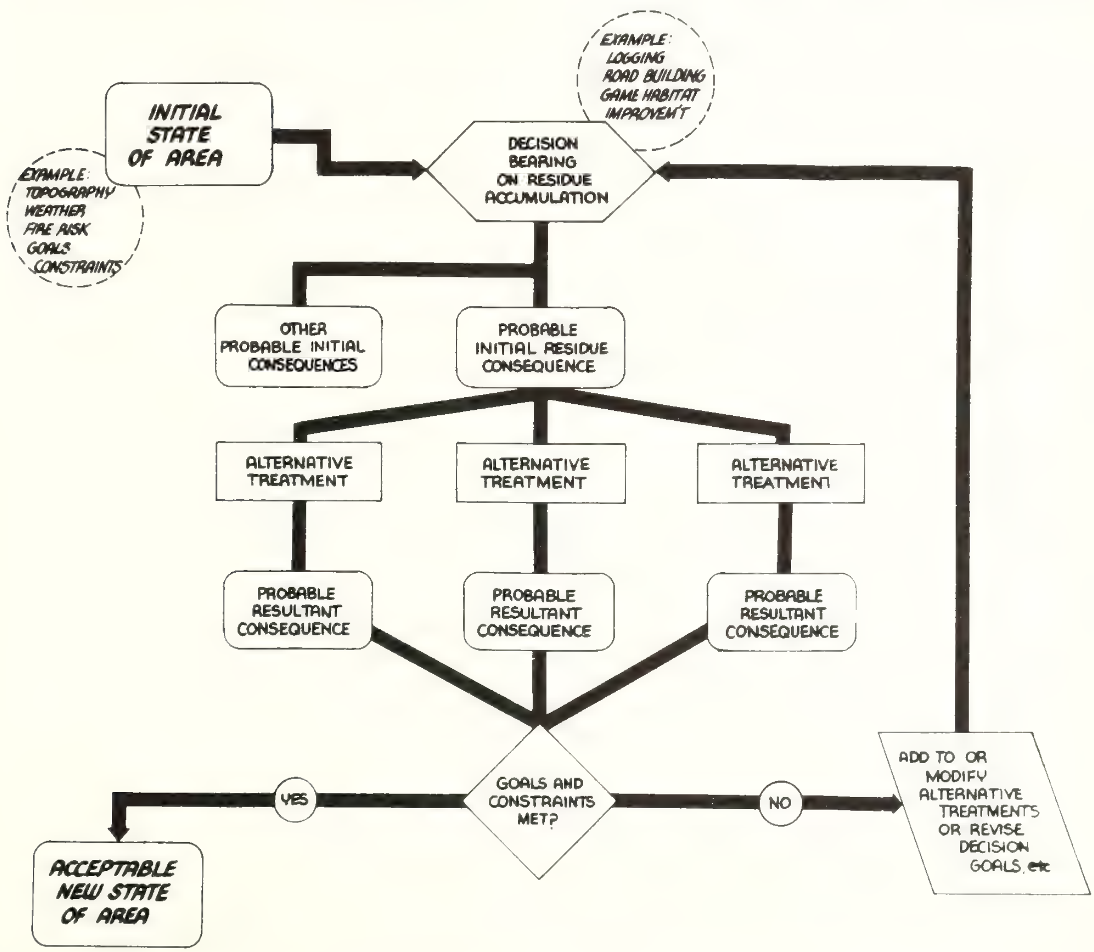

Figure 2.—Model of basic framework for evaluating alternatives and making residue treatment choices.

This framework permits a research and development team to analyze alternatives on relative scales based on subjective data, as is frequently necessary. Updating and refinement will be possible when more reliable research results become available.

Initially, it was believed that a set of quantified management goals for a given forest area, along with constraints, would be required in order to compare consequences of alternative actions. We now realize that the consequence blocks of the model can be portrayed, if necessary, even in descriptive terms for the critical elements. The results can be used directly by land managers to determine how well the consequences meet already established policy.

For example, the Multiple Use Management Guide (USDA Forest Service 1967) contains the statement: "Recognize natural beauty as a resource and to the fullest extent possible, manage all activities to retain or enhance its qualities." A general coordinating requirement of this nature may appear too broad for actual application in a system for evaluating alternatives. However, when each of the consequence blocks in the framework carries a statement of the effect of an alternative treatment on natural beauty, they can be compared with one another and with the coordinating requirement to be followed by the land manager, regardless of the values used.

The model can be translated into operational forms suitable either for evaluating relatively simple activities or for developing broad policy. On the one hand, a forest manager might perform a simple summing of costs and benefits; but on the other hand, large masses of data including probabilities would call for automatic data processing. An example of a segment of such an operational framework is illustrated in figure 3.

RESEARCH AND DEVELOPMENT LEADING TO INPUTS FOR THE FRAMEWORK

Several agencies, universities, and much of the forest products industry in the United States are devoting efforts toward meeting the challenge of forest residues. All of these may be regarded as inputs for use in a framework such as herein proposed. To quickly highlight some of these potential inputs, the following is a brief review of some of the work being done in the U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station.

PROBLEM OF UNUSED FIBER

A simulation model is being developed to study the feasibility of more complete utilization of residues in promising localities. Detailed inventories of residues according to several classes will be assembled. The economic feasibility of utilizing various kinds of residues will be projected. Expanded market opportunities will be investigated, including modification of existing plants and introduction of "satellite" plants to sort and grade low-quality wood and to manufacture products such as chips for pulping and particleboard. The results should indicate to landowners the kinds of residues that they can hope to market, and to loggers the kinds of residues that can be profitably removed and delivered to a processor. Processing firms will know whether raw material costs and processing costs will permit a profitable operation. A first priority in developing this model is to examine the feasibility of electric power generation.

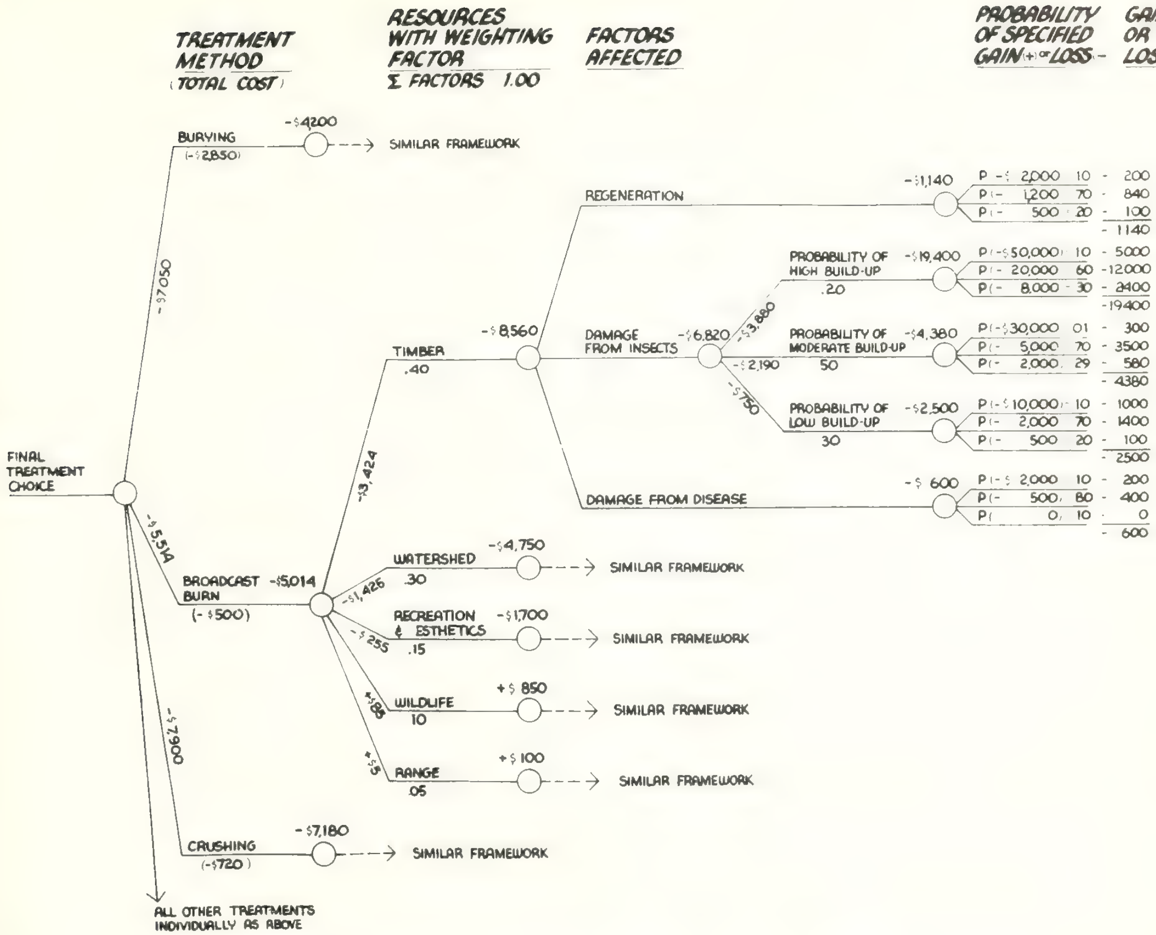

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Figure 3.—Segment of expanded operational framework.

Two aspects of selling public timber will be further explored and refined. Per-acre pricing of small trees and logs on National Forest timber sales has been used with success in some cases to significantly reduce amounts formerly left as residues. Formerly, buyers purchased all designated timber stumpage on a sale area by submitting a bid per unit of volume by species or species groups. Small logs of dubious quality and market value had to be paid for, and if they were left, a penalty was assessed. Prospective buyers can now submit a bid per unit of volume for logs suitable for lumber, plywood, or fiber. In addition, the buyer pays a stated amount of money per acre for small trees, which are not subject to bidding. Once paid for, the buyer has latitude in choosing pieces he wishes to remove, but an incentive exists for him to remove as much as possible because he has paid for all of it. Per-acre pricing is a shift toward lump-sum selling of timber based on the appraised value of tree inventory volume. Problems have resulted for the seller in deciding whether to include certain trees and logs in the per-acre priced material because buyers can increase the volume of this category by bucking trees into small-sized logs. Problems for the buyer are still related to high-volume production needs.

The second aspect of timber selling concerns changing the seller's emphasis

in a conventional timber sale from obtaining maximum initial revenue to that of replacing the harvested stand of timber with a site ready for stand regeneration. A trade-off of reduced revenue to obtain a cleaner site for forest regeneration is more consistent with the concept of intensive forest management. This sale modification needs to be tested to obtain data for use in the framework in evaluating an additional timber selling alternative. As visualized, the method would combine unit volume bidding for large valuable logs, per-acre pricing of smaller material to a stated minimum size, and making all other material available to the purchaser without charge. The purchaser would be required to yard all unused material larger than a stated size to designated places on the sale area. The availability of "free" wood coupled with a fixed cost for small logs could provide an incentive to purchasers to devise efficient ways for handling small and defective logs in order to market as much as possible of the material that is required to be moved.

OTHER PROBLEM AREAS

In order to assemble inputs for the framework in terms of costs and benefits, we sought knowledge already available. For certain alternatives, such as mechanical means of treating residues and fire control, numerous references in biological disciplines and engineering technology were found.

The conflagration control guide developed by Dell (1972) for use in the Northwest Region of the Forest Service is illustrative of a first result of our searching and combining what has already been learned. It conveys to practicing forest managers the best known techniques for prefire planning. It describes criteria for selecting strategic fire control locations and the best techniques for establishing fuelbreaks in advance. Other installations to aid initial fire attack and conflagration control are included: landings for helicopters, sources of water, and methods of fuel reduction over broad areas. This state-of-knowledge publication will help identify all alternatives and make possible cost data collection for the framework. Residue management can in this way become more than only fuel disposal.

A compendium is being prepared by a team of 20 forest scientists to evaluate previous studies on biological and physical effects of forest residues and residue treatment. High-priority research needs will be identified.

New knowledge also is being added by evaluating costs and effects of promising methods of residue treatment through tests on designated land management units. Although evaluations of treatment will depend on descriptive techniques to a large degree, they should provide interim data for the decision framework and identify specific needs for more controlled investigation.

CONCLUSION

The task of managing forest residues occurring under widely diverse situations can be complex. Almost any action to modify or dispose of residues influences all forest resources, benefiting some and impairing others. People likewise are affected by treatment of forest residues.

Numerous sources of information can be used by the forest manager to reach sound decisions in attaining specified forest management goals. Choice of the best combination of alternatives,

though often subjective, can be accomplished by using a relatively simple framework to systematize and evaluate courses of action. This same systematization will also make possible public involvement when environmental concerns call for more than emotionally based and abstract arguments.

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The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Development and evaluation of alternative methods and levels of resource management.
3. Achievement of optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research will be made available promptly. Project headquarters are at:

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The FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

General Technicl Report PNW-8 is bound separately.

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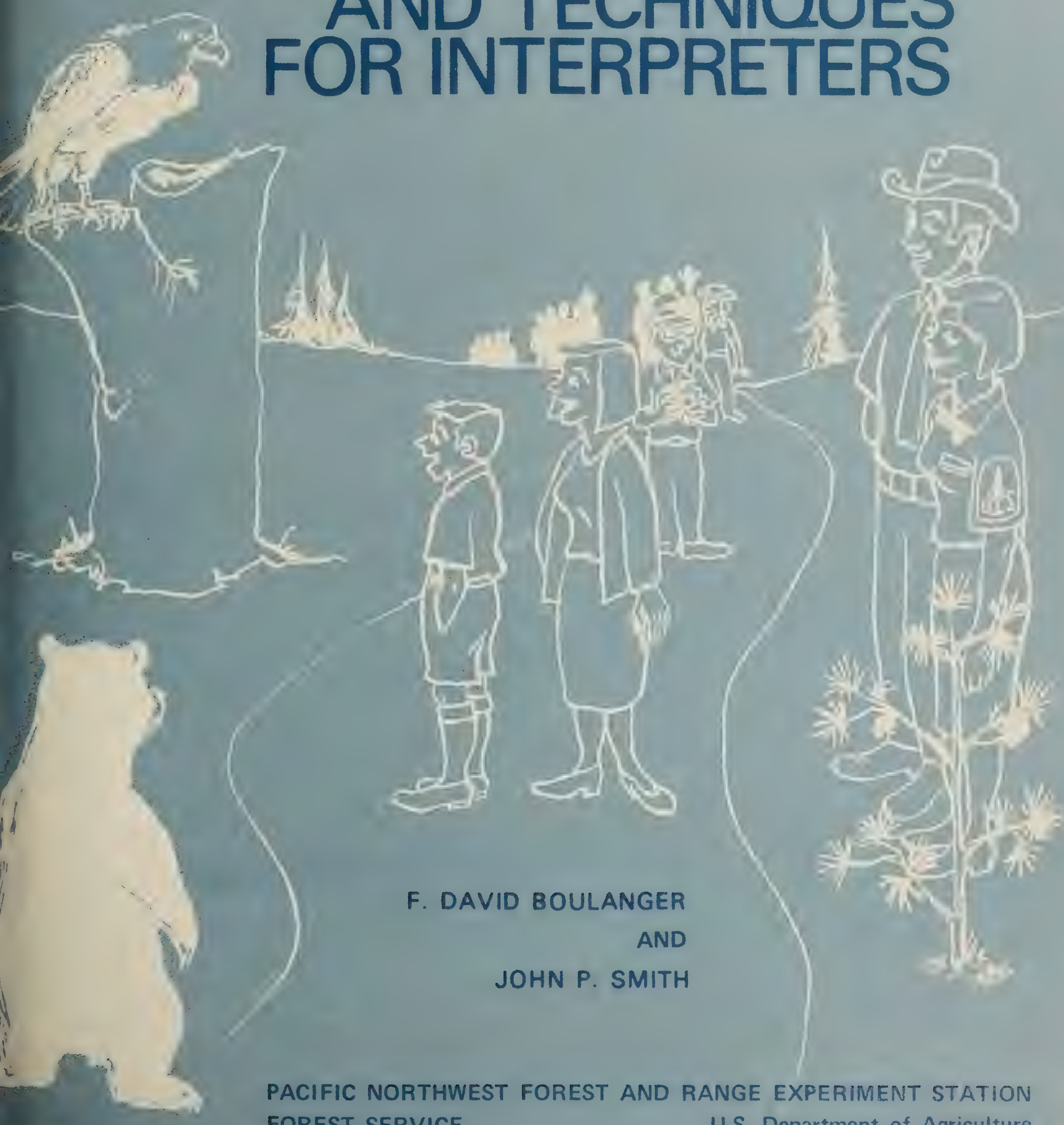
USDA Forest Service General Technical Report PNW-9

EDUCATIONAL PRINCIPLES AND TECHNIQUES FOR INTERPRETERS



F. DAVID BOULANGER
AND
JOHN P. SMITH

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE
U.S. Department of Agriculture
Portland, Oregon

ABSTRACT

Outlines principles and techniques for effective talks and discussions. Covers objectives, selecting and organizing visitor experiences, motivation and attention-holding techniques, use of questions, and use of examples, analogies, and metaphors. Includes a checklist and bibliography.

KEYWORDS: Natural history, educational psychology, environment, recreation.

AUTHORS

Dr. Boulanger is Assistant Professor of Curriculum Instruction, University of Illinois at Chicago Circle, and Dr. Smith is Associate Professor of Science Education, University of Washington, Seattle.

Illustrations by Harold W. Street

PREFACE

Interpretation is in large part education, since it attempts to convey information, concepts, and principles while creating attitude changes and such emotional states as wonder, delight, and appreciation. Although interpreters might profit greatly by formal training in the principles and techniques of teaching, many have not had such training.

Some means of making the insights of educators available to interpreters seemed essential. Therefore, the Environmental Interpretation Research Project arranged for F. David Boulanger and John P. Smith to write this booklet.

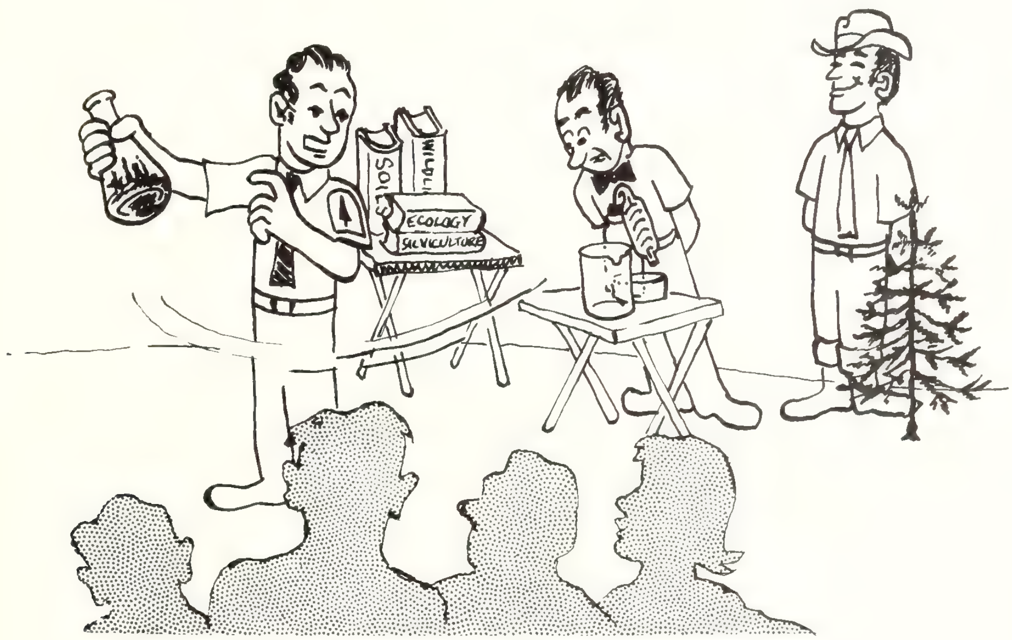
Although the authors draw heavily upon classroom approaches, most interpreters should profit from the attention given to realistic objectives and known techniques for stimulating learners. The authors outline the major principles, methods, and techniques developed by educators and provide a bibliography for those who wish added sources of information.

J. ALAN WAGAR, Project Leader
Cooperative Recreation Research
Pacific Northwest Forest and Range
Experiment Station

CONTENTS

INTRODUCTION

Your role as an interpreter of natural and cultural resources is increasingly important now that more and more people are trying to understand the dynamics, protection, and management of the environment on which we all depend. As an interpreter, you are a vital link between your visitors and the scientific and historic insights that can enrich their experiences when presented in enjoyable and understandable terms.



Like most interpreters, you probably are seeking better ways to reach your visitors but have not had formal training in teaching. To give you greater insight into teaching methods, this booklet summarizes basic educational principles and techniques that can be useful for interpretation. A checklist is provided on page 22 to help in your planning of presentations. References are given in the bibliography to help you find additional information.

The major premises of this booklet are:

Teaching is an art as well as a skill. This booklet emphasizes principles and skills.

Teaching involves a relationship between teacher and learner that goes far beyond the transfer of knowledge and includes such factors as mutual respect and understanding.

Active involvement of the learner is central to good teaching.

Your audience may be free to leave but will be motivated to stay and learn if the process is enjoyable.

Although entertainment is not a primary goal of teaching, ***good teaching can be entertaining***.

Some important terms are used in this booklet as follows:

A *CONCEPT* is a set of characteristics common to a class of objects or events. Concepts are identified by assigned names. For example, *erosion, habitat, clearcutting,* and *ecosystem* are all concepts.

PRINCIPLES are sequences of closely linked concepts or relations between concepts. An example is the statement: "Unrestricted erosion prevents new vegetation from rooting and growing." Nearly every word represents a concept.

KNOWLEDGE is a term that encompasses interrelated concepts and principles. Specific concepts and principles are usually organized around some broad concept such as forestry.

PROBLEM SOLVING means the application of concepts and principles to achieve some goal. Problem solving indicates learning beyond the level of concepts and principles.

A *SKILL* is the capability resulting from the repeated exercise of some physical or mental operation.

LEARNING implies that a visitor can describe appropriate concepts and principles in his own words or can apply problem solving and skills in new situations.

SETTING YOUR DIRECTION

When planning a trip, you first select objectives such as where you want to go and what you intend to do. When preparing an interpretive presentation for visitors, you also must first select objectives. With your objectives clearly defined, you can then assemble appropriate materials, outline content, and develop procedures to achieve your goals. ***In choosing objectives, then, consider audience characteristics and what you want to present and why.***

Audience Characteristics

Since effective teaching modifies the knowledge, attitudes, and skills of people, it is important to consider audience characteristics. What ages, educational backgrounds, occupations, and special interests are represented? Why are the people in the audience attending your presentation?

The more uniform the group, the easier to specify objectives. For example, molecular processes in trees might be right for visiting biology students, but probably too abstract a topic for 90 percent of a tourist audience. Since audience characteristics are often beyond your control, build enough flexibility into your objectives and plans to accommodate broad or even unexpected audience characteristics.

Deciding What To Present

Depending on the audience, you might emphasize concepts and principles, the research by which they were discovered and developed, or attitudes toward a topic. If your topic is bird life, for example, you might develop objectives around habitat and reproduction of local birds, methods for studying such concepts in the local environment, or why you enjoy studying birds and the feelings you have when watching bird behavior that few people ever see.

Write down as many objectives and points as necessary to make your intent clear. Consider the time available, your own strong points, the prior experience of the visitors, and what you want them to gain from the presentation. *Their gain* in ability is the measure of your success as an interpreter.

How much information should you present in the time available? As a rule it is better to limit concepts and principles and increase the number of concrete examples, visitor experiences, and opportunities for problem solving.

What are your strong points? Your own knowledge is important in your choice of objectives.

How does the topic relate to the day-to-day life of the visitors? Can you develop analogies that draw on things most of them experience in their daily lives? Are there controversial areas in which you might expect interest, questions, or challenges? Before plunging into controversy, consider what the audience might gain and whether the setting is appropriate.

Statements of objectives must define what your visitors should be able to do as a result of your efforts. In these statements, avoid words subject to a wide range of interpretation such as "to know," "to understand," or "to appreciate." If you have selected local marine life as the subject, a precisely stated objective could be: "The visitor should be able to describe, categorize, and compare local marine life according to feeding habits, reproduction methods, and typical habitats." This objective is stated clearly enough to aid you in selecting materials and outlining the presentation.

REACHING YOUR AUDIENCE

Although teaching or interpreting can range all the way from a well-defined interpreter-controlled situation to a broad dialog in which participants alternately teach and learn, the approach emphasized here is that which you control.

As an interpreter, you are a unique kind of teacher who seldom speaks to the same audience twice. Normally, you have only limited time with your visitors and seldom get well acquainted with them. On the other hand, you can polish your presentation with each new audience until you become very effective. These conditions usually limit your personal presentations to talks and discussions.

Talks

The talk or lecture is good for large audiences and for introducing or summarizing information gained from other sources. An introductory talk can tell your visitors what to expect in visiting the area or what to expect in subsequent talks. Such an introduction can set a positive tone for individual or group activities where understanding and insight can occur more easily. For visitors who have already been in the area or attended previous talks, you might plan another talk to summarize the concepts, principles, and insights gained.

POINTS ON PREPARING TALKS

Identify major concepts and principles to be learned. Use no more than four or five in a 1-hour talk and less in the more usual half-hour talk. Plan problem situations in which concepts and principles can be applied.

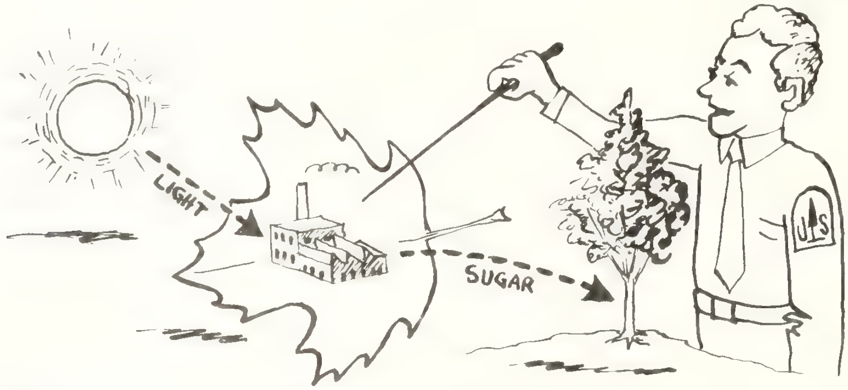
Choose and state objectives in terms of what the visitor should be able to do as a result of hearing your talk.

For each objective, decide what you will do and say to assure that your visitors will accomplish it.

Outline the talk on note cards or a sheet of paper. Your notes should include major topics and subtopics, key questions or problems for audience feedback, transitional statements, and cues for presenting specimens or visual aids.

Prepare an effective opening. For this you can use some of the "motivating and focusing" techniques explained in a later section.

Develop analogies and examples to illustrate difficult points. Your analogies should be taken from things within the experience of your audience. For instance, urban examples should be used in analogies for an audience of urban people. Be ready with alternative presentations in case audience feedback indicates puzzlement or misunderstanding.



Prepare a summary statement reinfocing major points in the talk. This statement could answer a question posed at the beginning or state another question to be left unanswered.

Rehearse your talk in private. If you plan to use teaching aids, practice handling them or operating them to avoid embarrassing breakdowns and delays during your talk. Indicate time allotments on your outline.

Use simple language, emphasizing major points by repetition.

Make your voice more interesting by varying pitch, loudness, and speed of delivery.

Prepare comfortable surroundings. With good ventilation, lighting, seating, and temperature, the audience can concentrate on your talk. Decide whether or not to allow smoking.

Other suggestions are given under "Specific Techniques."

Discussions

The discussion method works best with no more than 10 people. With a good leader who controls contributions to insure wide participation, up to 30 people can carry on a discussion. In larger groups, a vocal minority will do most of the talking.

Participants should have a sufficient information base to discuss a topic. Therefore a discussion might be especially suitable after a film, a field trip, or some other activity in which all members of the discussion group have participated.

In the discussion method we assume that each visitor has unique experiences valuable to the group and therefore should have the opportunity to contribute; that motivation for learning increases with participation; and that the individual will value and retain knowledge gained through personal interaction with others. The following suggestions should help you to plan and conduct discussions.

POINTS ON PREPARING DISCUSSIONS

Encourage participation and an informal atmosphere by arranging all participants facing each other in a circle. By joining the circle, you will emphasize your role as a participant. Be sure your visitors are comfortable.

Give an effective opening statement. You might summarize the preceding group experience, or you might open by a demonstration, by showing a provocative short film, by narrating a case study or anecdote, or by simply stating a question that requires thinking. In short, anything that creates doubt or question, or that offers the possibility of varied or conflicting responses, is a good way to begin.

Ask "higher order" questions that extend beyond simple memory and that require your audience to evaluate, infer, determine cause-effect relationships, and so forth. An example would be: "How have frequent fires affected the plants and animals in this forest?" Your questions should limit tendencies toward factual or rote learning by keeping the discussion at the concept, principle, and problem-solving level.

Don't answer your own questions. If you answer your own questions or give insufficient time for others to answer, you show that you are less interested in the group responding than in providing the right answer. Intervene too often and you may stifle discussion and discourage participation. Also, don't pass immediate judgment on each speaker's contribution.

Be receptive to feedback. Listen to your visitors. Determine their level of understanding and use the information to guide your remarks or questions.

Be ready to guide, refocus, and summarize. Guiding means insuring that everyone has an opportunity to speak and that no one, especially yourself, dominates the discussion. Guiding also means stimulating the discussion when a lull occurs and asking clarifying questions when a participant's point is not clear.

If discussion digresses, refocus on the central topic. You can do this by restating the original question or by asking a related question. Such questions should be developed and written down before a discussion. This means you must anticipate the alternative paths a discussion might take.

The summary of a discussion cannot be preplanned, since you do not know for sure where it will go or where it will end. You can record points to be summarized on a note pad. If the discussion has specific objectives, you may want to insure that each objective is summarized.

SPECIFIC TECHNIQUES

This section summarizes techniques useful for interpretation. You must decide when to apply particular techniques by using your own judgment and the principles discussed earlier.

Selecting and Organizing

One of the most creative aspects of interpetation is selecting and organizing experiences for your visitors. You must decide what kinds and sequences of experiences will best achieve your objectives.

One way to examine the content and sequence of a presentation is to ask, "What must the visitor already know to deal with this idea or experience?" For example, explanation of food chains may need to precede a discussion of DDT's effects on peregrine falcons. Other useful principles for selecting and sequencing content are:

Proceed from the simple to the complex (as from the one-celled to the many-celled organism);

Proceed from the whole to the parts or vice versa (as from the ecological system to component processes or the reverse);

Present a chronological development (as in explaining the formation of geological structures);

Illustrate increasing breadth of application (as in showing the concept of balanced land usage, first for the forest, then gradually expanding it to include farms, suburbs, cities, and an entire region);

Progress from the familiar to the unfamiliar (since the urban dweller understands "home" he can readily understand "habitat");

Move from the seen to the unseen (from watching a beaver building a dam to describing the details of a beaver's anatomy that allow tree cutting and prolonged underwater excursions);

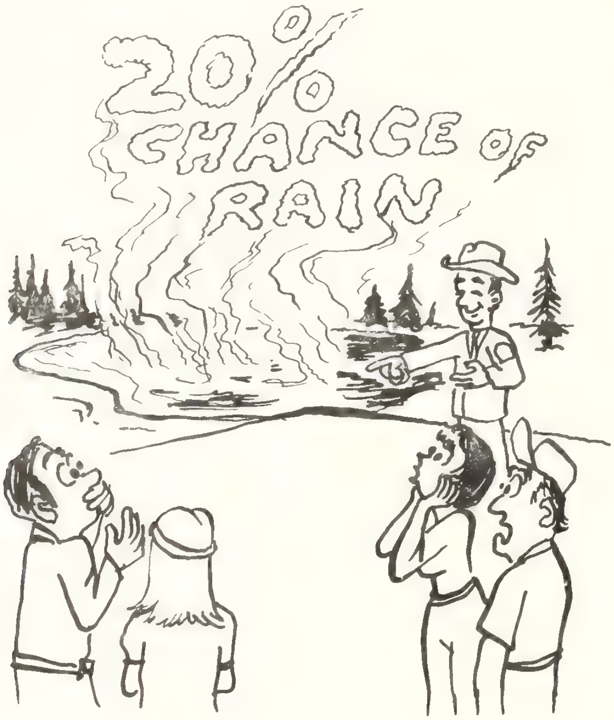
Simply let the visitor decide his own sequence of learning experiences, as is possible, for example, with the multifaceted display.

Motivating and Focusing

While you talk, your visitors have little chance to participate actively. They can become bored or distracted if you don't create a lively opening and then hold their attention. You can stimulate active listening with opening or transitional statements using some of these techniques:

Promise valuable knowledge or skills. Tell your visitors how this knowledge will be valuable to them by giving examples or by confronting them with situations in which they might realistically find themselves. For example ask, "What would you do if you came upon a mother bear with two cubs while hiking on a trail?" Such openings are useful when objectives involve practical knowledge and skills, as in topics about survival training, lifesaving, or forest management.

Arouse curiosity. Use an opening statement such as, "The local Ranger says he can predict tomorrow's weather by simply observing the mist on Basin Lake. Meteorologists were skeptical until they compared the factors influencing local weather with the factors influencing mist on the lake. In today's talk we will find out why Basin Lake is such a good weather indicator." Once the audience is curious about the relationship between the lake and the weather, it will be eager to share your knowledge.



Use several senses (sight, hearing, touch, smell, taste) relating such interesting objects as plants, rocks, soils, or animals and their habitats to your topic. If first-hand contact is not possible, provide pictures, illustrations, a demonstration, or a tour.

Ask provocative questions which your presentation will at least partially answer. For example: "How many salmon would you guess swim up this ladder each hour? Who can describe how a glacier is formed? What is the oxygen-carbon dioxide cycle and how is it evident in this pond?"

More ideas for provocative questions are given under "Questioning Techniques" below.

Identify discrepant events, that is, pieces of information that do not seem to fit logically into a story or explanation. For example, you could focus the attention of your audience with the following: "As more people use this area, the bear population,

rather than being scared away, increases." The explanation might be obvious to the forest-oriented person but not to the average visitor.

Use your visitors' natural desire for completeness. Give an incomplete illustration, film, picture, explanation, list, or example to create a desire to know the untold or unknown part. Your presentation should then fill in the facts, concepts, and principles needed for complete understanding.

You could create a symbolic "black box" to represent an unknown process. State the input and output. The presentation will center on what happens inside the "black box." For example, input: new power plant; output: diminished fish population.

The basic rule in motivational openings or transitions is to make the statements or problems factual and to pose related questions that can be answered from the talk to follow. If you can't think of an appropriate opening, you should make a straightforward, enthusiastic statement of what your visitors should be able to do as a result of the talk.

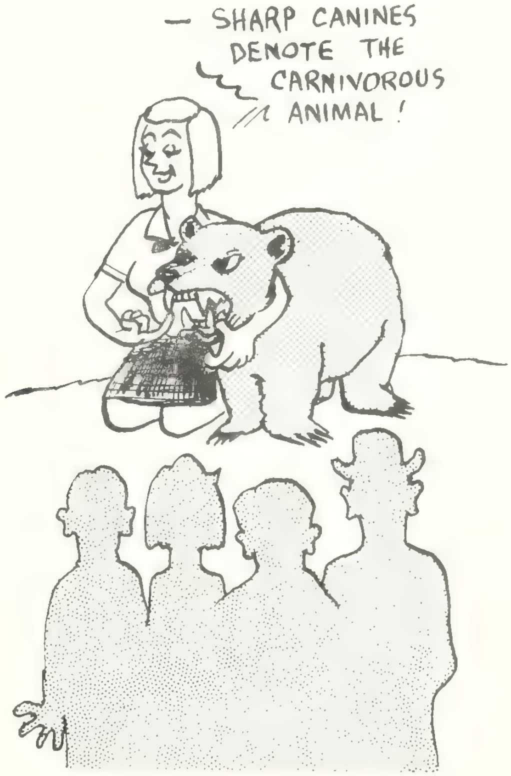
Using More Than Words

Words are never as effective as first-hand sensory experience. To bring your talk to life, use real specimens, demonstrations, visual aids, or on-site visits. When you talk to a group in a natural setting, choose your stopping places and position yourself so that the entire audience can hear you.

Getting Feedback

In informal settings and small groups, you can easily determine your visitor's comprehension and interest by listening and asking questions. Such "feedback" is more difficult to obtain in talks to large groups.

One way to get feedback is to stop after several minutes of talking and ask, "Any questions?" Or you can pose a problem whose solution requires the information you have just presented. For example, after talking about cloud formations, you might describe a set of climatic conditions and ask, "What kind of clouds would you expect under these conditions?"



The answers, or even the silence of your audience, provide valuable feedback that permits you to adjust the remainder of your talk. If the audience does not respond to your questions, you have one or more communication problems: the presentation may be too difficult; the question may be inappropriate (not answerable using the concepts and principles you have presented); or your visitors may feel timid in a large group or even alienated by your behavior.

You can repeat the question after giving more information. If you still get no response, you may have unconsciously created a barrier. To avoid this, be sure you don't put your audience in a defensive or inferior position, making people feel threatened or hostile toward you. Also, don't antagonize people by showing an air of detachment, by using unfamiliar words, or by talking down to them, as in emphasizing how obvious and easy a topic is to understand.

Subtle reactions also provide feedback. In order to observe and use this feedback, you must be so well prepared that you can divide your attention between talking and scanning the audience for expressions of interest, puzzlement, or boredom. This means referring only occasionally to notes and observing your listeners while displaying visual aids. Skill at interpreting nonverbal expressions and gestures will come with practice.

Questioning Techniques

An interpreter asks questions for a variety of reasons. You may want to determine what your visitors know about a subject, promote interest in a subject, obtain feedback on your teaching strategy, or merely provide a change of pace during a talk.

Once you decide what kind of response you want from your visitors, you can guide their thoughts by skillful questioning.

MEMORY QUESTIONS

Memory questions are basically of two kinds. Factual questions ask for recall of specific memorized information or experience. They often begin with *who, what,* or *where.* For example, "What is soil erosion? Where have you observed it?"

Descriptive questions are more complicated and usually require longer answers, but they are still answerable from memory or sensory experience. For example, "Can you describe the process of soil erosion?"

PROBING QUESTIONS

Probing questions ask the visitor to analyze, expand, or clarify his response to a preceding question. Probing questions may:

1. ***Seek clarification*** as by asking, "What exactly do you mean? Could you elaborate on that point?"

2. ***Increase critical awareness*** by asking a person to justify his response. For example, "What are you assuming? What are your reasons for thinking that is so? How would an opponent of this view respond?"

3. ***Refocus the response.*** For example, "If this is true, what are the implications for . . . ? Can you relate this to . . . ?"

4. ***Prompt your visitor*** by giving him a hint to help him answer a question.

HIGHER ORDER QUESTIONS

Higher order questions cannot be answered merely from memory or experience. They ask the learner to generalize, to relate facts, to compare and contrast concepts or principles, to make inferences, or to perceive causes and effects. Higher order questions ask the learner to discover principles, not just define them; to use ideas rather than just remember them. They are particularly appropriate when your objectives involve concepts, principles, and problem solving.

Imaginative use of higher order questions can enliven an otherwise dull presentation. Decide what kind of thinking you want to stimulate and select the most suitable kind of question.

You can use higher order questions to ask for:

1. ***Evaluations.*** An evaluation question requests judgment, value, or choice. It may or may not include a statement of standards. A standard is included in this example: "In terms of recreational value, which of these three areas do you believe should be preserved in its natural state? Why?" Without the reference to recreational value, your visitors could assume their own standards for judging.

2. ***Inferences.*** When you provide certain information and ask the visitor to reason his way to a conclusion, you ask for inferences. For example, deductive reasoning would be required by the following: "Precipitation occurs when moisture-laden air rises to high altitudes. Relate this principle to our local climate." A question requiring an inductive inference would be: "We have found soil acidity at several points around the camp. What might we conclude about the condition of the soil in this area?"

3. ***Comparisons.*** In a comparison question you ask whether ideas or objects are similar, dissimilar, unrelated, or contradictory. The simplest kind asks in what way two or more objects are identical, as: "In what way is man like the ape?" Another tests the degree of similarity between ideas or objects: "What are the similarities and differences between dog tracks and fox tracks?" A third asks a person to relate sets of ideas on similar points: "Compare the life style of the bumblebee with that of the ant."

4. ***Application of concepts and principles.*** You can test your visitor's understanding of a concept or principle by asking him to use it in a new context. For example, "Can you apply this principle of ecological succession to your own garden plot?"

5. ***Problem solving.*** Problem-solving questions require the use of previous knowledge to solve a new problem and often demand much creativity. For example, "Given this information, how would you solve the food shortage problem?"

6. ***Cause-and-effect relationships.*** These questions ask a person to find a link that connects one event or object with another. For example, "How is the disappearance of this animal related to man's entry into this area?"

DIVERGENT QUESTIONS

Divergent questions are open-ended and require your visitors to explore the unknown, to think creatively. The process may be more uncomfortable for you than for your visitors, because you cannot classify the answers as right or wrong. You and your visitors must free yourselves to explore new ideas and possibilities. An example of a divergent question would be: "How might you use this plant to help you survive in the wilderness?"

GENERAL RULES OF QUESTIONING

These general rules of questioning apply to all categories of questions:

1. Distribute questions widely among your visitors so that many are encouraged to speak. If necessary, redirect a question to several visitors to bring them into the discussion.

2. Balance the kinds of questions asked by using factual, probing, higher order, and divergent questions as appropriate.

3. Encourage visitors to give detailed responses. Ask questions that require such answers and follow with probing techniques.

4. Allow ample time to think over a question.

5. Ask clear and coherent questions. Frequent rephrasing should be unnecessary.

6. Encourage your visitors to confer with each other as well as with yourself.

7. Ask questions that require more than a "yes" or "no" answer.

Attention-Holding Techniques

Your visitors' attention may wander during a talk or lecture. Some techniques for holding their attention are suggested here. Try to develop techniques that fit your personal style.

GESTURES: Hand, head, and body movements are important in communication. Your verbal message is more effective when combined with gestures and facial expressions.

FOCUSING: You can focus your visitors' attention on significant objects, ideas, or events by gestures combined with statements. You might move toward an important object or diagram or point to it and say, "This feature is really important!" or "Look carefully at this diagram."

PAUSES: A deliberate pause during your presentation can be an effective attention-getter. Your audience will strain for cues alerting them to your next statement. Also, moments of silence break the presentation into more easily absorbed units.

SHIFTING SENSORY CHANNELS: Your presentation will be more vivid if it appeals to many senses. Use visual aids such as displays, film, or a blackboard. Or you can ask your visitors to handle such specimens as a rock or a live snake.

MOVEMENT: Allow your visitors a refreshing change in vision and hearing by changing your location. Requiring your listeners to adjust their vision and hearing to your movements helps maintain a high level of attention.

Use of Silence

Silence has subtle effects that can be used to advantage. Silence after an introductory statement suggests that the statement is important and has stimulated your audience to think about it. Silence after a question from a visitor indicates that you are considering the question and that the rest of the audience should do the same. It is courteous to be silent for a few moments after asking an audience or individual a question, thus allowing time to think of an answer.

Use of Nonverbal Cues

Nonverbal communication occurs whenever you address a group or an individual. Moods and attitudes such as pleasure, interest, puzzlement, weariness, and tension are communicated by nonverbal signals and may support or oppose your objectives. Here are some common examples:

1. *FACIAL EXPRESSIONS:* Surprise, approval, doubt, anger, and a wide range of other messages are sent automatically by your facial expression. A very powerful channel of communication, facial expressions are instantly understood by your audience.

2. *HEAD MOVEMENTS:* Nodding, a shake of the head, or a cocked ear all communicate standard meanings to your audience.

3. *GESTURES:* Besides holding attention, gestures can be used to augment your verbal message. Commonly recognized body motions can say, "Are there any questions?" or "Continue" or "I really don't know."

Use of Examples, Analogies, and Metaphors

You can use examples in two ways. One way is to state an idea or principle first and then illustrate it with clarifying examples. The other way is to give examples first and ask your audience to infer the general principle. In either case, you might give examples by using visual aids or by using analogies or metaphors.

An analogy emphasizes similarities between an object or event that is already understood and one that is not. For example: "An artesian well is like a burst water main." Be careful not to stretch analogies too far. Point out their limitations and imperfections.

A metaphor is a word or phrase applied to something to which it is not literally applicable. For example: "That animal is a bag of bones."

The following are guidelines for effective use of examples:

1. ***Start with the simplest examples*** and work toward complex ones. If you begin with complex examples, your audience may become confused by excess information and miss the point.

2. ***Use examples from the experience and knowledge of your audience.***

3. ***After presenting some examples, offer an irrelevant example.*** Recognizing negative instances is important in understanding a concept.

4. ***Don't assume the more examples you give the better.*** New examples should provide new information about the concept.

5. ***Be sure the relationship between the example and the idea is understood.***

6. ***Ask your audience for additional examples.*** This way you can make sure they understand the concept.

Use of Reinforcement

Whenever you respond to a statement or question, you may feed back to your visitors' approval (positive reinforcement), a neutral acceptance, or disapproval (negative reinforcement). With many people, especially children, your response can encourage or discourage the repetition of an act. Be conscious of the power of reinforcement whenever you seek contributions from your visitors.

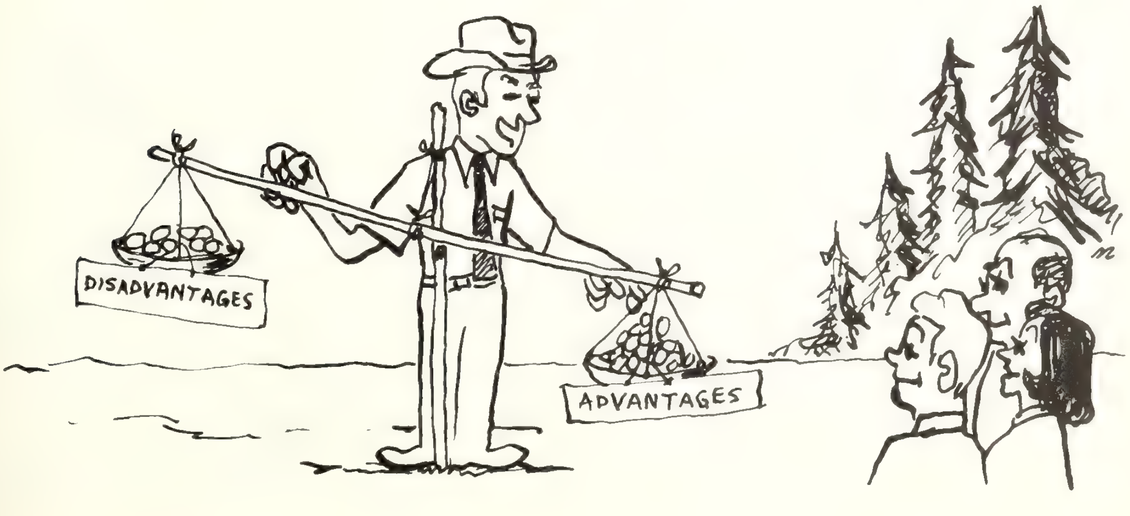
Examples of positive verbal reinforcement are terms like "good" or "excellent." Some positive nonverbal reinforcers are a nod of the head, a smile, sustained eye contact, and movement toward the speaker.

Handling Attitudes and Values

Attitudes and values depend in part on factual information, but often they are transferred in subtle ways. Your enthusiasm for the subject, your sensitivity to audience reactions and questions, and your care in preparing your presentation will all influence your visitors' attitudes toward the subject.

Remember, significant changes in attitudes and values rarely occur during a short presentation. However, if you are comfortable with your audience, and if it is not too large for discussion, you may want to discuss attitudes and values directly. Before doing this make sure you are not rigid in your own attitudes and examine the assumptions on which your attitudes toward the subject are based.

One way to make attitudes and values visible in a nonthreatening way is to quote two opposite views on a controversial or value-laden issue and describe opposing viewpoints. These views can be drawn at the ends of a line representing a spectrum of viewpoints.



Then invite individuals to express their own positions on the issue. You can remain entirely neutral during this process and stimulate discussion by asking such leading questions as:

"Under what circumstances do people holding this view begin thinking this way? Were they influenced by social contacts, news media, institutions, or anything else?"

"What assumptions about the place of man in the natural environment are implied in this viewpoint?"

"What might be the short and long range consequences if this viewpoint were to dominate forest management policy?"

"What other values should be considered when taking a position in this controversial area?"

When leading this kind of discussion, you should be open to diverse points of view, either remaining neutral yourself or advocating a moderate position. If you alienate half of the group by taking a strong position, the discussion may not be worth the loss of group confidence. Of course you can take a strong position as an obvious "devil's advocate," thereby forcing people to rethink their positions. However, you must be careful not to embarrass or antagonize your visitors by sarcasm or irony.

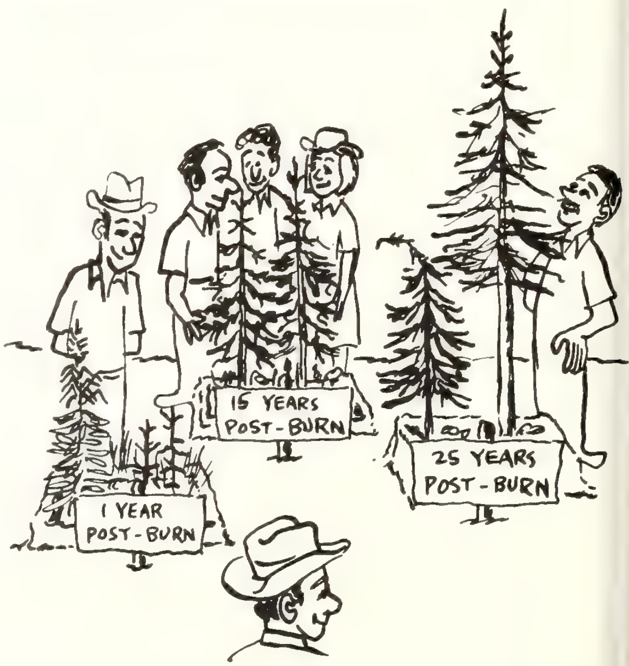
A Final Example

The following example suggests some general guidelines for planning a presentation.

Suppose your objectives are that your visitors will be able to identify the grasses, shrubs, and trees that compose the stages of forest regrowth following a forest fire, to describe the influence these stages exert on wildlife in terms of food and habitat, and to describe how modern fire-suppression efforts have altered the natural "fire-ecology" cycle in the past 30 years. Also you want to create an attitude that "all fires aren't bad," and that experimentation with controlled burning might hold potential benefits for both man and the environment. The general plan of the presentation might be:

1. Display specimens of the small plants and grasses, shrubs, and trees in order of their succession following a fire. Attach question-asking labels or signs to the specimens.

2. Show live specimens or illustrations of local forest wildlife, asking questions about the habitat and food preferred by each.



3. Show slides or a movie emphasizing the dependence of most wildlife on open areas and the scarcity of wildlife in old mature forests.

4. Describe how the huge wildfires of the past are now prevented by efficient suppression methods and how the game ranges that were created by those fires are being lost under a canopy of trees.

5. Conduct a brief walk to an observation point or provide directions to sites where different stages of forest regrowth are visible.

6. Throughout the presentation, ask questions and pose problems. To leave your visitors with a sense of wonder, the presentation should end on an authentic open-ended question which to your best knowledge has not been answered by anyone.

Several principles of learning are evident in this example:

1. *Individuals differ as much in their interests and styles of learning as they do in their personalities.* Diverse appeal is built into this presentation through the use of

examples, illustrated descriptions, visitor activities, and the use of differing media. Also the visitors can associate the content of each stage of the presentation with the medium used to present it, thus aiding memory.

2. *Repetition of concepts and principles via different media helps the learner assimilate new knowledge.* In this case, each stage of plant succession, its characteristics, and its value as a wildlife habitat might be encountered two or three times in different contexts.

3. *Learning is enhanced if the process begins with concrete examples and involves as many senses as possible.* Seeing and touching the specimens are excellent ways to begin.

4. *People are stimulated to think when they encounter an obstacle or challenge.* Concepts and principles learned in a problem-solving situation are better retained than if simply memorized. Also, by posing problems or higher order questions, you can determine whether concepts and principles were learned. Your success at teaching can be measured simply by observing how well your visitors reason their way to conclusions.

5. *People like to participate in the choice and planning of learning experiences.* Additional displays or printed material expanding the central concepts and principles could be included to allow more individual choice.

CHECKLIST

The following checklist should help you prepare your presentation. Page numbers refer to the text of this booklet.

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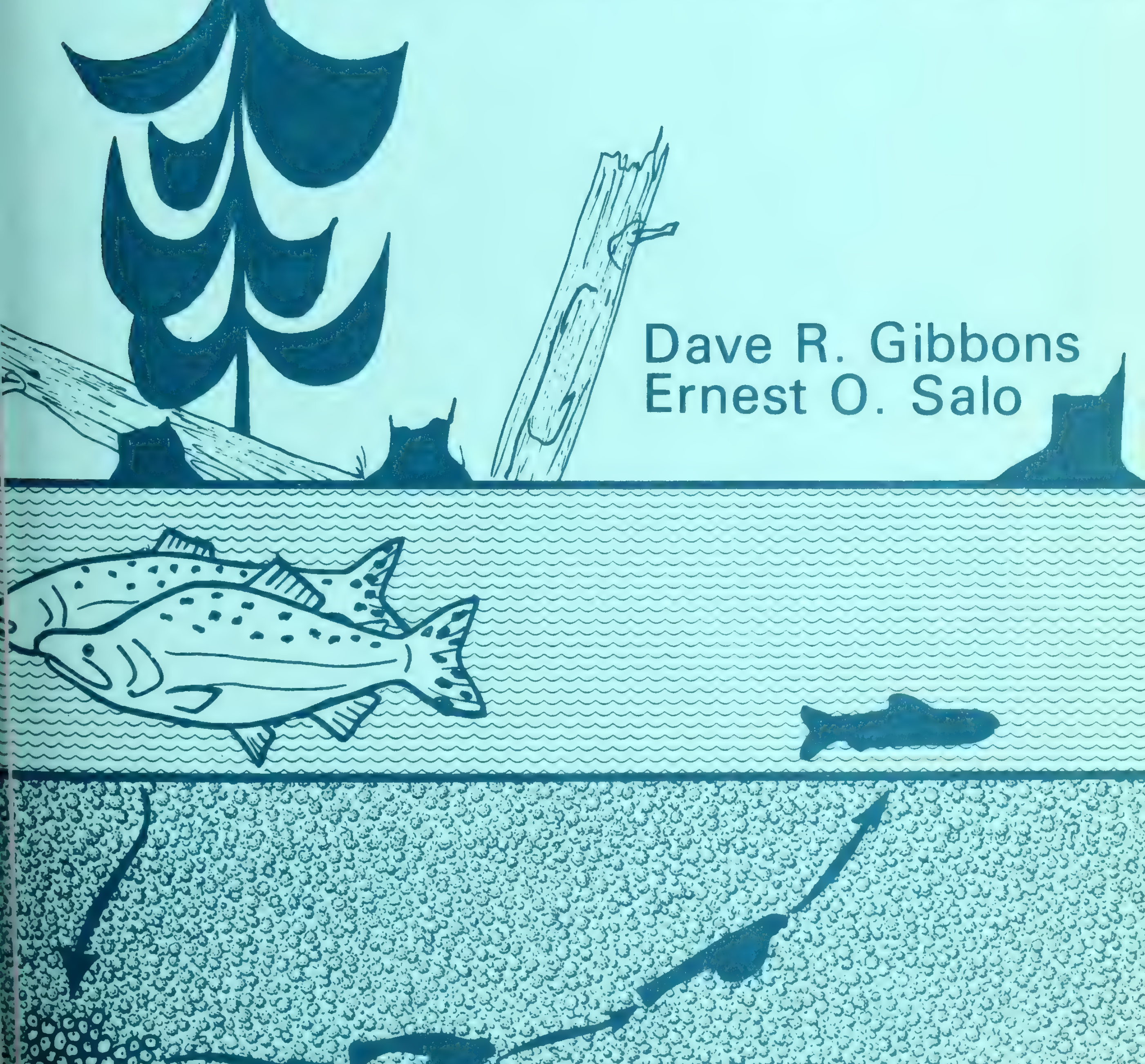
1973
USDA Forest Service General Technical Report PNW-10

AN ANNOTATED BIBLIOGRAPHY OF THE EFFECTS OF LOGGING ON FISH OF THE WESTERN UNITED STATES AND CANADA

Dave R. Gibbons
Ernest O. Salo



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ABSTRACT

This bibliography is an annotation of the scientific and nonscientific literature published on the effects of logging on fish and aquatic habitat of the Western United States and Canada. It includes 278 annotations and 317 total references. Subject areas include erosion and sedimentation, water quality, related influences upon salmonids, multiple logging effects, alteration of streamflow, stream protection, multiple-use management, streamside vegetation, stream improvement, and descriptions of studies on effects of logging. A review of the literature, a narrative on the state of the art, and a list of research needs determined by questionnaires are included.

This bibliography includes reports involving pesticides published by many agencies. Recommendation for use of these pesticides is not implied, nor that the uses discussed have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CONTENTS

A REVIEW OF THE LITERATURE ON LOGGING AND FISHERIES--
A STATEMENT ON THE STATE OF THE ART

This narrative on the "state of the art" of the effects of logging on fish of the Western United States and Canada consists of two parts; the first is a review of the literature; the second, an analysis of a workshop on logging and fisheries held at the University of Washington, November 20-21, 1972. The numbers in parentheses indicate references in the annotated bibliography developed from the literature.

INTRODUCTION

There is no question that, historically, certain logging and associated land-use practices have had deleterious effects upon freshwater and anadromous fish populations. It is evident that some of these detrimental practices are continuing, although many others have been discontinued. A tremendous amount of progress has been made. Man's activities, coupled with naturally occurring events such as forest fires, floods, and slides, generate complexities that are difficult not only to assess but to control. Obviously, continuous assessment of potential environmental impacts is the concern of the land-user as well as of the resource manager. On the other hand, the ability of the management biologist sometimes is limited by ignorance of the requirements and status of fish stocks inhabiting the waters in question. This ignorance may range from the lack of knowledge of the peculiarities of the life histories of the endemic fishes in the streams and of the basic productivity of streams to the role of nonlogging factors such as fishing. In the absence of precise information, the biologist is inclined to recommend conservative regulations as a safety factor to protect the fish resources. Multiple uses of resources such as by fisheries and forest harvesters have, in the past, been conflicting; however, recently, the two groups have attempted to enter into coordinated research and management.

REVIEW OF THE LITERATURE

Sporadic research was conducted on the effects of logging and related use on the ecology of streams from 1900 to the 1950's. Since that time, extensive research has been conducted by many agencies. As productive as the research has been, it is still not possible to generalize on the effects of logging because of the varied land and aquatic habitats found in the Western United States and Canada. The hazards of logging to fish and water resources of the Pacific coast have seldom been quantitatively defined; in most cases, the potential harm was only inferred. Definite problems have been recognized in the literature. The

harmful effects on fish which can result from logging and poor silvicultural methods used on the Pacific coast include:

1. Introduction of sediments

    a. Bedload sediments

        (1) reduced dissolved oxygen caused by reduced inter- and intragravel waterflow
        (2) physical barrier to the emergence of alevins
        (3) lowered production of aquatic plants and invertebrates
        (4) damage to eggs by adhesion to the chorion
        (5) reduced catchability of sport fish

    b. Suspended sediments

        (1) erosion of gill membranes
        (2) degradation of rearing habitat
        (3) lowered production of aquatic plants and invertebrates

2. Altered streamflow regimes
3. Introduction of logging debris

    a. Barriers to movement by juveniles and spawning adults
    b. Reduced dissolved oxygen as a result of high biological oxygen demand

4. Degradation of rearing habitat through streambank erosion
5. Altered temperature regimes

    a. Increased summer temperatures
    b. Decreased winter temperatures

6. Alterations in stream energy resources
7. Indiscriminate use of pesticides and herbicides
8. Altered chemical water quality regimes by the exposure of mineral soils and indiscriminate use of fertilizers.

The sources and effects of erosion and sedimentation have received the greatest research emphasis (fig. 1); however, the general topics of water quality, alteration of streamflow, stream protection and improvement, and the environmental requirements of salmonids have also received considerable discussion and documentation within North America. The research conducted before and after 1960 has shown similar emphases but with increased emphasis on water quality after 1960 (fig. 1).

Sources of Literature

The majority of the research results have been published in symposia or by academic institutions; however, considerable quantities can also be found in biological and forestry journals and in publications by the U.S. Forest Service and State agencies (table 1).

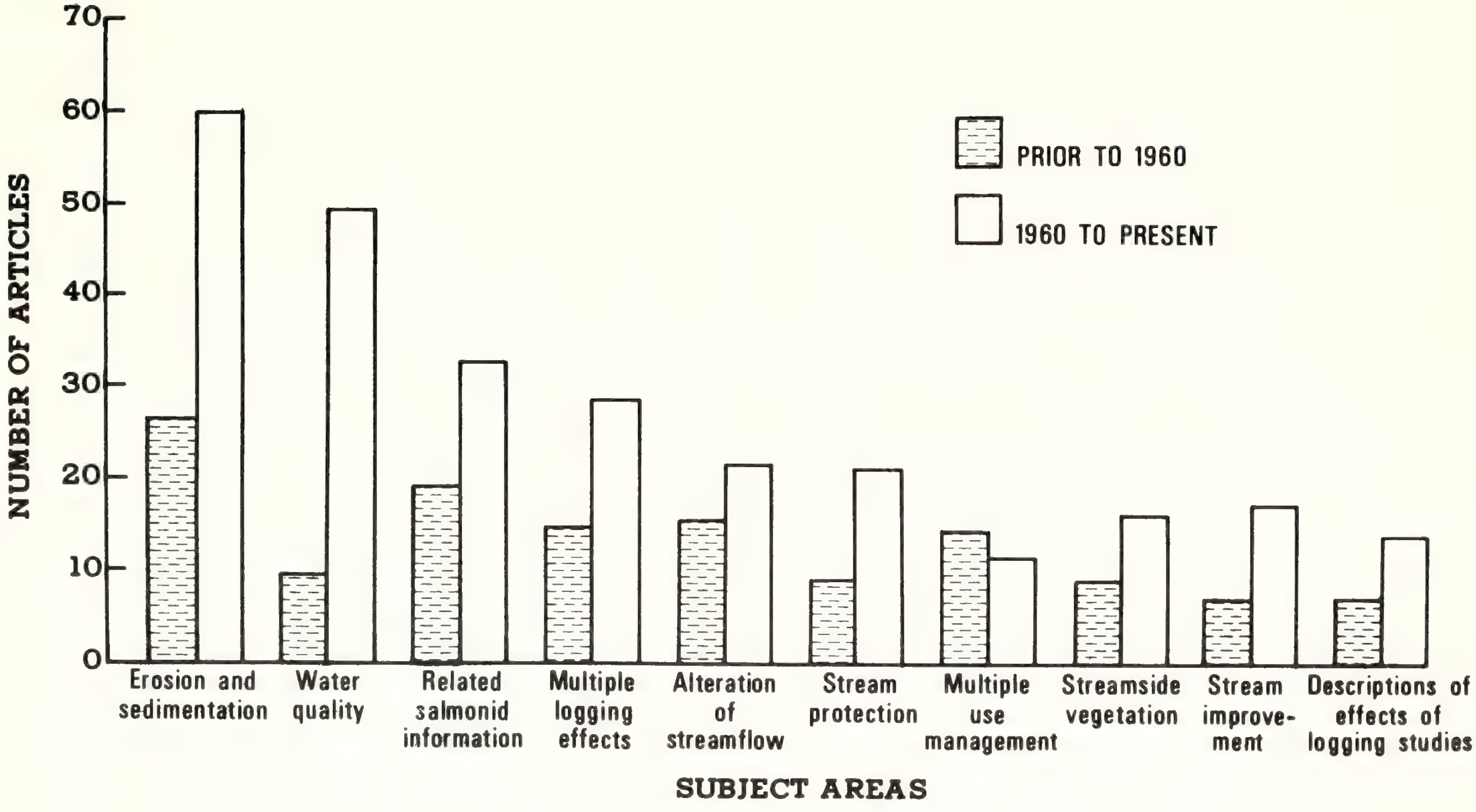

Figure 1.--*Research conducted on the effects of logging in the Western United States and Canada.*

Table 1.--Literature concerning the effects of logging on fish, 1928-73

Categories	Number
Symposia and academic institutions	83
Biological journals	60
Forestry journals	60
U.S. Forest Service publications	59
State agencies	49

Analysis of Literature

An analysis of the literature shows that although some critical analyses of the detrimental effects of logging are in the scientific literature, most blanket condemnations of logging are found in the popular, nonscientific journals. Actual quantitative, documented evidence on detrimental effects of logging on fish populations is limited to seven articles (*56*, *61*, *152*, *153*, *175*, *177*, *211*).

Many unpublished data are present in the files of fisheries management agencies. The results of many research summaries can be classified only as inconclusive. Table 2 is an attempt to categorize the conclusions of articles which appraise logging and silvicultural practices; 118 articles were not included as they do not fit the classifications chosen. Recent publications on the effects of logging have been less critical than in the past, perhaps as the complexity of the problem has become better understood. There seems to be a recent change in attitude favoring prevention instead of rehabilitation and an increase in collection of data for integration into watershed models.

Table 2.--Categorization of articles which appraise logging practices as described in the literature

Rank	Category	Number of articles	Percentage
1	Data collection on the effects of logging leading to inconclusive results	63	33
2	Description of adverse logging practices	58	30
3	Prevention of adverse logging practices	37	19

Table 2.--Categorization of articles which appraise logging practices as described in the literature--continued

Rank	Category	Number of articles	Percentage
4	Undetermined as to the effects of logging	10	5
5	Reviews of literature	8	4
6	Quantitative evidence of the detrimental effects	7	4
7	Condemnation of logging	5	2.5
8	Beneficial results of logging	5	2.5
	TOTAL	193	100

LITERATURE SUMMARY

Sedimentation

Most articles on sedimentation of streams have been purely descriptive, and sometimes dramatic, in their portrayal of an adverse effect on the environment. A lesser number of articles have reported qualitative effects of sedimentation. Quantitative studies of sedimentation, although few in number, have provided the real basis for present knowledge and can be divided into two categories: its sources and its effects on stream environments.

Sources of Sediment

Erosion, landslides, and the occurrence of sediments in our waters are natural phenomena and vary with the inherent erodibility of soils, geology, climate, and vegetation. Man's activities can, and usually do, accelerate these natural processes. The summation of approximately 25 articles documenting the effects of logging and logging roads on sediment production indicates: (a) logging roads are the greatest source of man-caused stream sediments; (b) sediments from clearcuts occur infrequently and are primarily a result of bared mineral soils and reduced surface-soil permeability due to compaction; and (c) severe burning of logging slash is often followed by increased rates of surface soil erosion, due primarily to the removal of stabilizing vegetation and litter.

The diverse characteristics of watersheds prevent extrapolation of results over wide geographical areas. Stephens (*50*) stated that "because of the striking differences in watershed characteristics, most of the published research results on the effects of logging on streams from other areas cannot be extrapolated directly to Southeast Alaska." Recently, however, some researchers through quantitative measurements of soil characteristics, meteorology, topography, and land-use conditions, have provided a basis for predicting differences in sediment production (*2*, *5*, *51*).

Continuous research needs to be conducted on the development of new or redesigned logging methods that require fewer roads and produce less soil disturbance.

Effects of Sediment on Aquatic Environments

Fluctuations in the characteristics of aquatic environments, including the numbers and diversity of organisms, are natural phenomena. Through time, organisms have become selectively adapted to life within a set of environmental parameters. Changes which exceed the natural tolerance of these organisms will drastically change the population. The severity of stresses imposed by man upon the adaptability of these organisms will determine the degree of change.

Suspended sediment--The summation of six available articles dealing with the direct effects of suspended sediment or turbidity on fish, mostly salmonids, demonstrates several mechanisms of damage, including: (a) the adhesion of silt particles to the chorion of salmonid ova (*29*) and (b) the abrasion, thickening, and fusion of gills as a result of increased silt concentration (*295*). In addition to direct mortality of fish, suspended sediment also blocks or decreases light penetration and thereby limits the production of phytoplankton and other aquatic plants. It may also cause alterations in stream temperature-change rates and precipitation of organic particles which produce high stream BOD (Biological Oxygen Demands). Another concern is the loss of sport fishing time as a result of increased turbidities. It has been stated that fishing success declines with increasing turbidity above 25 ppm (*43*).

The literature demonstrates a large variation in results, making it impossible to define precisely what levels are lethal. Generally, prolonged exposures to concentrations from 200 to 300 ppm are lethal to fish. Shorter exposure times to concentrations of 90 to 810 ppm may reduce survival through synergistic effects with other stresses (i.e., increased temperature and decreased dissolved oxygen) in the environment (*16*, *295*). This research on the direct effects of suspended sediment on fish has been conducted in the laboratory and bears questionable applicability to field situations.

Future research should emphasize: (a) more detailed laboratory studies of the mechanisms of damage to fish from suspended sediments, (b) quantitatively documented studies in actual field situations, and (c) studies of the adaptability of salmonids in glaciated streams vs. natural streams subjected to increased suspended sediment concentrations.

Bedload sediments--Of all the factors affecting aquatic life, bedload sediments cause the most damage. The smothering effect and instability of sediment reduce invertebrate diversity and populations (*55*, *56*, *198*, *199*), reduce available living space for fish (*29*, *43*), and reduce early survival of fish (*184*, *195*, *211*).

A summation of the findings from 50 articles dealing with bedload sediments shows: (a) sediment fills gravel interstices, thereby reducing inter- and intragravel waterflow, reducing dissolved oxygen to incubating salmonid ova; (b) deposited sediment can physically prevent emergence of fry (fig. 2); and (c) sediment reduces food resources by filling gravel interstices and promoting unstable substrates for aquatic invertebrates and periphyton communities.

Research has indicated that the lethal effects of sediment are most pronounced during the developmental stages of fish while in the gravel, and that once hatching occurs, physical environmental factors become less important and food availability becomes more important. Research on the effects of sediment has been quite extensive, as shown by the literature reviews of Cordone and Kelley (*15*), Gebhardt (*289*), Hollis et al. (*29*), and Koski (*32*). In spite of the fine work that has been completed, there still exist serious gaps in data documenting the quantities of sediment altering stream productivity related to fry quality and survival.

Organic sediments--Organic fines introduced by logging are important in stream environments where they decrease dissolved oxygen concentrations and intergravel flows and increase salmonid ova and alevin mortalities through the promotion of the growth of *Sphaerotilis* (bacteria which attack fish gills, resulting in suffocation). Suspended conifer fibers have been shown to lower the survival of rainbow and brown trout fry by inhibiting gill functions (*95*).

Water Quality

The watersheds of the Western United States and Canada harbor some of the most productive salmonid populations in the world. In the past, forest management has focused primarily upon the production of timber with little regard for maintaining stream quality; and consequently, water quality in many streams has been degraded. Logging and silvicultural practices have resulted in changes in the physical and chemical characteristics of water, e.g., increased water temperatures and the addition of silvicultural chemicals.

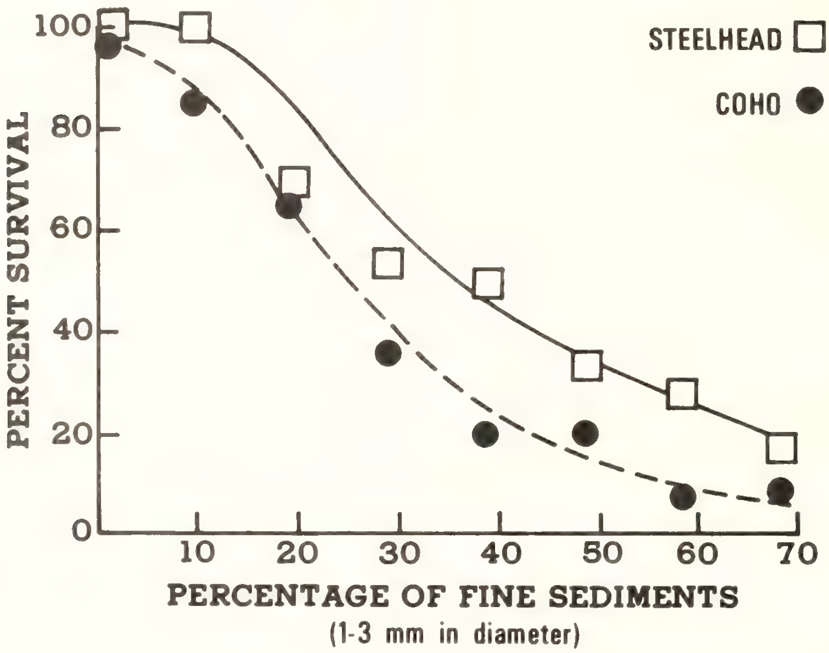

Figure 2.--*The relation between amount of fine particles in an artificial gravel bed and the ability of coho salmon and steelhead trout fry to emerge through the gravel* (211).

Water Temperature

Water temperature is a parameter that has received considerable attention recently in reference to land-use studies. Water temperature has been proven to be a major determinant in the suitability for salmonid production, with small forested streams being the most susceptible to a temperature change (*78*, *80*, *90*). As well as inducing direct mortality of organisms, adverse water temperature influences the level of dissolved oxygen and nutrients; controls algal blooms which may impart taste, odor, color, and ecological changes; and affects growth, condition, and behavior of fish. Warm water is also conducive to the growth of bacterial species which may constitute health problems to humans and fish. Finally, prolonged alteration in the temperature regime may eventually alter the species composition of streams.

A summation of 22 articles concerned with the effects of logging on stream temperature indicates: (a) removal of streamside vegetation increases maximum water temperatures by exposing streams to increased direct solar radiation; (b) stream temperature (Δt in °F) is directly proportional to surface area exposure (A in ft^2), the solar energy input (H in B.t.u./ft^2/minute) and inversely proportional to the flow (D in c.f.s.):

$$\Delta t = \frac{A \times H}{D} 0.000267 \qquad (77);$$

(c) warmed water reaching shade does not normally cool unless there is an inflow of cool water; and (d) winter minimum water temperatures can be lowered through removal of streamside vegetation (*84*).

Any change in the temperature regime of small streams may be deemed detrimental by some, but moderate increases in temperatures have been suggested by others as a means of improving salmonid habitat. However, care must be taken to prevent eutrophication and the destruction of salmonid habitats.

Future research should determine: (a) the effects of streamside vegetation removal on winter stream temperatures in the Western United States, and (b) the different effects of various cutting practices on water temperature.

Chemical and Physical Properties

The chemical and physical properties of stream water under natural conditions vary with the geology of the watershed through which it flows. Degradation of water quality can occur naturally due to leaching of mineral elements and humic acid compounds but often is induced by man's activities. Water quality can be affected by logging through accelerated leaching of nutrients from soil and wood and through the introduction of silvicultural chemicals.

Nutrients--Aquatic organisms require organic and inorganic nutrients which originate primarily from the terrestrial forest system. It has been shown that there is relatively little elemental loss from undisturbed forest soils in the temperate regions. Timber harvesting and silviculture can, however, increase the leaching rates. A summary of 15 relevant articles discloses: (a) increased loss of chemical nutrients from the soil follows logging and slash burning; however, these nutrient additions to the streams are only temporary and dissipate with stream dilution, flushing, and removal by aquatic organisms; (b) leaching rates of nutrients can be affected by topographic and meteorological features of the watersheds, by soil textures, and by the degree of clearcutting; (c) leachates from stored logs vary with the volume and flushing rate of the storage site, number, species, and age of logs stored, and can produce fish mortalities; and (d) the levels of nutrients observed in streams after timber is harvested appear to be below the toxic thresholds for aquatic organisms.

Some researchers have advanced the idea that the addition of nutrients to a stream may be beneficial, especially to relatively sterile streams by supporting additional plant and animal life, but such results are difficult to predict and may result in eutrophication.

Research needs include: (a) the acute and chronic effects of nutrient leaching on aquatic organisms, (b) the absorption or adhesion of nutrients to stream sediments, and (c) the quantification effects of documented nutrient addition.

Forest chemicals--Intensified forest management practices may include the utilization of a large number of chemicals including fertilizers, herbicides, and insecticides. A summary of 16 articles dealing with the use of chemicals indicates: (a) direct aerial application to surface waters is the major source of forest chemical pollution; (b) unless application is made directly to the water, the major potential for contamination is heavy rain resulting in overland flow and sedimentation; (c) insecticides are the most dangerous and have adversely affected aquatic communities; and (d) herbicides and fertilizers generally can be used safely if not applied adjacent to or in streams or lakes.

Further research should include: (a) the acute and chronic effects of specific forest chemicals on aquatic organisms and (b) the reactions on aquatic organisms of solvents, carriers, or other additives introduced with the forest chemicals.

Streamflow

Streamflows in coastal areas of the Western United States and Canada are primarily affected by precipitation patterns and somewhat less by evapotranspiration losses (*138*). The removal of vegetation by timber harvesting increases streamflows, since the reduction in evapotranspiration losses is much greater than the possible evaporation from increased soil exposure.

A summary of 26 articles relating to streamflow shows: (a) streamflows increase after clearcut logging, especially if followed by slashburning; (b) for every 1 percent of watershed cut, an average increase of 0.2 inch in water runoff can be expected the first year after cutting (*126*); (c) minimum flows are increased, although major flood flows are not significantly increased; and (d) changes in streamflow resulting from vegetation removal are, in most cases, less than natural climatic-caused variations (*138*).

The effects of altered streamflows may be either detrimental or beneficial to aquatic stream organisms. Increased flows cause egg and alevin displacement and mortality as a result of gravel shift and reduce benthic algae and insects by gravel grinding actions and displacement. Increased flows will expand the available living space for fish and insects and thus increase the carrying capacity. Increased summer flows will also lessen the adverse effects of increased solar radiation on stream temperatures due to vegetation removal.

Environmental Requirements of Salmonids Related to Logging

Pacific salmon and trout comprise the major constituents of the upper trophic levels in stream systems of the Western United States and Canada.

Due to the breadth of the information on the environmental factors affecting these salmonids, no attempt will be made to summarize this information. There are, however, excellent reviews including articles by McNeil (*182*), Neave and Wickett (*187*), and Wickett (*195*).

Early studies attempted to evaluate the effects of logging on stream environments by comparing the numbers of adult salmon returning to logged watersheds. These studies were not capable of discerning causes and effects because they were masked by a fluctuating saltwater survival, and freshwater mortality caused by sedimentation, floods, droughts, and temperature changes. For example, it has been reported that changes in an adult salmonid population of less than 50 percent due to any one cause would be difficult to detect within the large natural variations (*162*). Recently, it has been suggested that cutthroat trout be considered as an indicator species, due to their sensitivity to small changes (personal communication, Richard L. Lantz).

There is still a lack of information and understanding of population dynamics and inventories of fish stocks. The problem is immense but must be made tangible and applicable to timber harvesting and silvicultural practices.

Future research should include: (a) case-history-type studies that contribute to more general models of land use, (b) *in situ* studies of tolerances and effects of water temperature on salmonids and resident fishes, and (c) accumulation of basic data on the inventories and carrying capacities of streams.

Ecological Effects

Trophic relationships of stream systems are complex but, as in all ecosystems, depend primarily on sunlight. Light energy reaching the stream and its borders is fixed by terrestrial vegetation and algae. The algae and terrestrial plant detritus dropping into the stream are eaten by aquatic organisms, primarily insects; and in turn, the latter are eaten by fish. Timber harvesting has been shown to disrupt this system.

A summary of 11 articles dealing with general ecological effects indicates: (a) removal of streamside vegetation can shift the populations of insects from detrital feeders to algal feeders; (b) the beneficial effects of increased solar radiation upon algal production may be offset by the loss of terrestrial plant detritus; (c) terrestrial insects as a food resource can increase as a result of clearcut logging; and (d) shifts in stream algal flora can occur as a result of clearcut logging.

Future research should examine how biotic and abiotic changes affect stream communities. This implies longer and more detailed biological monitoring.

Streamside Vegetation

Research has shown that clearcut logging can significantly affect salmonid streams, particularly the small ones. These effects can, in some cases, be prevented if a protective strip of vegetation (buffer strip) is left along the stream.

A summation of 16 articles dealing with buffer strips indicates that they: (a) provide shade, preventing adverse water temperature fluctuations; (b) prevent logging debris from entering streams; (c) provide streambank stability; (d) maintain natural water quality; and (e) provide food resources [organic detritus and insects] to the stream organisms. The role of tree canopy becomes less important with increasing volume of water and with channel width.

Most recent Federal and State timber sales require buffer strips along streams where fish and water quality are considerations. Buffer strip designs vary with specific situations according to timber species, soil type, terrain, rainfall, and strength and direction of prevailing winds. It is not necessarily essential for commercial timber to be left in a buffer strip if adequate shade can be provided by shrubs and other species of trees, and if the commercial timber can be removed without destroying the needed shade and streambank stability. The width of the buffer strip required will depend upon the shading ability of the streamside vegetation. A method for determining the optimal width for buffer strips has been developed utilizing an angular canopy densiometer to measure maximum shading ability (canopy density) (*62*). This method considers only width as a means of temperature control; protection from other disrupting factors may require modifications in the buffer strip boundaries.

Needs for future research include: (a) evaluation of factors involving windthrow in buffer strips and development of preventive designs, (b) comparison of deciduous vs. coniferous trees in buffer strips, and (c) rate of deposition and role of coniferous needle decomposition in stream ecosystems.

Watershed Management and Stream Protection

Soil and water are the two most important resources of the United States and can be beneficially or detrimentally affected by watershed management. The soil conditions and productivity that logged watersheds currently possess are more the result of chance than proper watershed management. However, this situation is changing since earlier preoccupation with "forest management" is being transformed into "watershed management."

A summary of 36 articles dealing with watershed management and stream protection indicates that logging and related activities can be compatible with fertile, stable soils and salmon-producing streams if adequate consideration is given during both planning and operational stages. There have been many management guidelines recommended by Federal and State agencies for resource protection. The most important management requirements are: (a) a detailed plan of the best methods of harvesting, considering all resources; (b) coordination with all other resource users; (c) budgeting manpower and money wisely, since the best management methods may not be the cheapest; and (d) surveillance and supervision of the timber harvesting and silvicultural operation as it progresses.

Biologists and other interested groups must help to determine the type of protection required, and managers must plan the harvesting procedure so that all necessary protection is afforded if effective watershed management can be attained.

Stream Improvement

Stream rehabilitation and improvement must be considered in the same light as most of the other factors discussed; i.e., each stream should be treated as an individual case, based on its specific characteristics. Most of the stream rehabilitation or improvement presently conducted is in conjunction with, or a result of, timber harvesting and is concerned with the removal of natural or man-caused log jams and logging debris.

A summary of 16 articles concerning stream improvement discloses that logging debris and jams can adversely affect: (a) fish passage, (b) stream gravel stability, (c) intergravel and intragravel dissolved oxygen and waterflow, (d) chemical water quality [tannins and lignins], and (e) stream productivity.

The first concern should be to keep logging debris out of streams; however, this problem is not as great as it used to be. Watershed management should now be concerned with the removal of logs in relation to fish spawning and rearing, chemical and physical water quality, stream productivity, and recreational and esthetic values. Research is needed to determine the best ways to conduct stream improvement in conjunction with logging operations.

Summary of Research Needs as Determined from the Literature Survey

I. Sedimentation

- A. Sources
  1. Development of new or redesigned logging roads
- B. Effects on aquatic environments
  1. Suspended sediment
     - a. More detailed laboratory studies of the mechanisms of damage to fish
     - b. Quantitatively documented studies in actual field situations
     - c. Studies of the adaptability of salmonids in glaciated streams vs. natural streams subjected to increased suspended sediment
  2. Bedload sediments
     - a. More studies filling the gaps in the data documenting the quantities of sediment altering stream productivity related to fry quality and survival

II. Water Quality

A. Temperature

1. The effects of streamside vegetation removal on winter temperatures
2. The different effects of various cutting practices on water temperature

B. Chemical and physical properties

1. Nutrients

a. Further studies on the acute and chronic effects of nutrient leaching on aquatic organisms
b. Absorption or adhesion of introduced nutrients to stream sediments

2. Forest chemicals

a. The acute and chronic effects of specific chemicals on aquatic organisms
b. Reactions of solvents, carriers, or other additives introduced with forest chemicals on aquatic organisms

III. Environmental Requirements of Salmonids Related to Logging

a. Case-history-type studies that contribute to more general land-use models
b. *In situ* studies of tolerances and effects of water temperature on salmonids
c. Accumulation of basic data on the inventories and carrying capacity of streams

IV. Ecological Effects

a. A more thorough and detailed analysis of the biotic and abiotic changes of streams as a result of logging

V. Streamside Vegetation

a. Evaluation of factors involving windthrow in buffer strips and development of preventive designs
b. Comparison of deciduous vs. coniferous trees in buffer strips
c. Studies on the rate of deposition and rate of coniferous needle decomposition in stream systems

VI. Stream Improvement

a. The determination of the extent of stream clearance in relation to the stream and the aquatic organisms
b. The development of methods to conduct stream improvement in conjunction with harvesting procedures

ANALYSIS OF THE WORKSHOP OF NOVEMBER 1972

A workshop of interested scientists and resource managers was assembled to attempt to define the major problem areas and research deficiencies in the analysis of the effects of logging. Although neither the discussion nor a written survey disclosed either a unanimity of opinion or any definite mandates, several needs became evident, although their priorities did not.

Abstracts of Presentations and Discussions Presented in Order of Appearance

Quentin Stober (Fisheries Research Institute, University of Washington)

Dr. Stober discussed the work of the International Biological Program (IBP) in watershed and ecosystem modeling and management.

Milo Bell (College of Fisheries, University of Washington)

Professor Bell's book, entitled "Fisheries Handbook of Engineering Requirements and Biological Criteria," and written for people involved in river management and structural factors, was discussed. The book was published by the U.S. Army Corps of Engineers in Portland, Oregon, in February 1973 but is very difficult to obtain.

Brian Allee (Quinault Resource Development Program, Taholah, Washington)

An outline of the work on the effects of logging on the Quinault Indian Reservation and some aspects of a preliminary low resolution land-use model were presented. The model is intended to: (a) elucidate the interactionary areas of forest harvesting and fisheries resources, (b) depict short-term vs. long-term strategies in land planning, and (c) estimate the recovery rates of aquatic populations as functions of land use.

James Burns (California Department of Fish and Game)

The Department of Fish and Game has conducted little logging research in California since 1969. However, they are presently working on legislative acts which are a result of an appeals court ruling on September 16, 1971, which declared the forest practices acts unconstitutional. In the areas of research, Mr. Burns feels that quick field monitoring methods and a stream classification system are necessary in California for proper stream protection.

Gene Deschamps (Washington State Department of Fisheries)

Mr. Deschamps provided a review of the State of Washington's hydraulic code which gives the Fisheries Department power to control activities in or near streams. A hydraulic permit is required for all

activities involving streams which must, in turn, be reviewed and approved by the Departments of Fisheries and Game. Mr. Deschamps also stated that little basic or applied research is presently being conducted. However, some inventory work on the streams in the State is in progress.

Don Lee Fraser (Washington State Department of Natural Resources)

Mr. Fraser presented the idea that there must be a balance between stream protection and log production in the State of Washington. The State should apply a cost/benefit analysis to obtain the maximum benefit from our resources. In addition, legislation is needed to define and standardize rules and procedures for the timber harvester. He emphasized the need for more "basic" research to determine the actual impacts of present-day logging methods.

Richard Lantz (Oregon State Game Commission)

Mr. Lantz reviewed the work conducted on the Alsea watershed and a broader monitoring program for 12 coastal streams. With the completion of these studies in October 1973, the Oregon State Game Commission will analyze the results and incorporate them into a new Forest Practices Act.

Gene Haydu (Weyerhaeuser Company, Longview, Washington)

Dr. Haydu presented a quick overview of his present and past research including a literature survey on the effects of logging on water quality. In conducting the survey, he encountered few studies which dealt with the impact of timber harvesting and land management on water quality and as a result such research is presently underway. Dr. Haydu's summary of research needs emphasized the meaningfulness of present water quality criteria. In essence, he felt there is a need for more factual data to establish a "realistic" set of water quality criteria.

Joseph Krammes (U.S. Forest Service, Arcata, California)

Mr. Krammes reviewed the present work being conducted by the U.S. Forest Service on fish habitat improvement in California. This work primarily deals with the installation of culverts to rehabilitate stream sections lost as a result of past road construction. Life history studies on anadromous fish present are also being conducted with results indicating the importance of ephemeral streams to fish production. Mr. Krammes also suggested a need for research to quantify the effects of timber harvesting, such as the conditions under which sediment or increased water temperature is a pollutant.

William Meehan (U.S. Forest Service, Juneau, Alaska)

Dr. Meehan summarized the research previously conducted, including: (a) the effects of logging on stream temperature, (b) methods by which sediment reaches streams, (c) effects of forest chemicals on aquatic organisms.

Leon Murphy (U.S. Forest Service, Portland, Oregon)

Mr. Murphy is concerned with the management of forest resources and their values as being directly proportional to its applicability to on-the-ground management objectives. He suggested that we examine and improve methods of communication and transfer of data among researchers, managers, and technicians (loggers). He also felt there should be an application of existing data and a pooling of professional knowledge to establish management directions. The solutions to effects of logging problems will not be provided by researchers or managers separately; there must be cooperation before optimum management of our resources can be achieved.

Thomas Chamberlain (Canadian Fisheries Service, Department of Environment)

Dr. Chamberlain discussed the probable use of a modeling system to integrate past research conducted in other areas with present research findings from the Carnation Creek study (located on Vancouver Island) to provide a management scheme suitable for the forest resources of British Columbia.

David Narver (Canadian Fisheries Service, Pacific Biological Station)

Dr. Narver reviewed the research presently in progress in British Columbia at Carnation Creek on Vancouver Island. The research was initiated to: (a) evaluate the guidelines presently in use in British Columbia; (b) attempt to understand a west coast overmature rain forest-salmon-trout ecosystem and how this system can be affected by logging and silvicultural practices; and (c) recommend forest management practices to optimize the watershed resources of fish, timber, and water. The study is designed as a long-term project with road construction scheduled for winter 1974-75 and timber harvesting to commence in 1975 and continue for the next five years.

Jack Rothacher (U.S. Forest Service, Corvallis, Oregon)

Mr. Rothacher presented a brief summary of his work in Oregon on effects of logging on streamflow and water quality; chemical changes in water quality after burning, logging, slash treatment, and forest chemical applications; and the development of new logging techniques. He also mentioned his present work with IBP and Dr. George Brown's study on the effects of finely divided logging debris on small coastal streams, including some work on its toxicity to fish.

William Sheridan (U.S. Forest Service, Juneau, Alaska)

Mr. Sheridan discussed three major problem areas confronting managers: need for more research, application of existing information, and dissemination of information. He also considered the need for studies in Alaska on the effects of logging on wildlife, especially rare and endangered species. Mr. Sheridan also discussed the use of interdisciplinary teams to achieve optimum land use and management, an idea he feels is a major breakthrough in land planning.

Bruce Pease (Fisheries Research Institute, University of Washington)

Mr. Pease described his research on the effects of log dumping and rafting in Southeast Alaska, including examination of present and past log dumping and rafting sites. His laboratory work with the comparative analysis of the leaching rates of the four major species of timber of Southeast Alaska and his present work with the acute toxicity analysis of these leachates to pink salmon were also discussed. The results of these studies are now available.

K V. Koski (Fisheries Research Institute, University of Washington; presently with U.S. Forest Service, Juneau, Alaska)

Mr. Koski described and discussed the work conducted at the Big Beef Creek chum salmon spawning channel located on Hood Canal at Seabeck, Washington. The channel provides for controlled experiments concerning the effects of gravel composition on mortality and condition of emerging fry. Generally, there is a decreasing percentage of survival of chum salmon fry with an increasing percentage of fines of less than 3.0 mm. He believes the results from these studies can be used as a predicting tool for the effects of sediment depositions in natural streams.

Richard Tyler (Fisheries Research Institute, University of Washington)

Mr. Tyler reviewed the preliminary results of a summer field study conducted in Southeast Alaska in 1972 on small logged and unlogged salmon-producing streams. Results showed that water temperatures increased more rapidly in logged than in unlogged streams; temperatures reached as high as 24.2°C for short periods of time; juvenile coho salmon and Dolly Varden char populations were apparently unharmed by the temperature peaks; a 50-percent reduction in streamflow due to drought resulted in a fourfold increase in time of net water transport; and aquatic insect diversity appeared to be unaffected by logging.

Summary of the Workshop

A preliminary questionnaire distributed to those attending was used to rank needs for research, general considerations, and management. Under research, basic stream ecology (including fish census data and data for classifying streams) received highest priority. From the resulting discussions as well as the questionnaire, one can assume we just don't know enough about our fish populations, especially those in logged watersheds. The most frequent question was: "How can changes in populations be measured if the effects are subtle and our knowledge of dynamics is deficient?" Life history research which is directly applicable to land-use problems is definitely needed.

Under general considerations, the need for more short-term studies (less than five years) was emphasized, rather than several isolated long-term studies. The need for a long-term plan (regional rather than by watershed) was brought out, possibly with a readily modifiable model which would be supplied by "case history studies" to answer specific questions.

The last area of consideration was management. A need for improved communications between management agencies and timber harvesters received the highest rating. Several other priorities were also quite evident, the first being the application of existing data. This includes two major aspects: (a) making existing data available to any and all agencies or researchers and (b) preserving the availability of the data. It was suggested that perhaps a small system or model for the exchange of information and continuity of research be developed.

Another priority was the need for a stream classification system to enable resource planners and managers to make the proper decisions regarding stream management. Possible classifications include: (a) stream productivity, (b) sensitivity to disturbance, (c) watershed geology and composition, or (d) fish producing capabilities and present standing stock.

A second questionnaire sent after the workshop to those who had attended produced similar results.

The exceptions in the similarities between the two questionnaires were in the category of research, with an increased emphasis on buffer strips and the effects of sediment on aquatic organisms. A combination of priority and feasibility values was used to determine needs, with feasibility implying a combination of available knowledge and realistic cost values, and priority implying a need for research. Categories receiving a high priority but a low feasibility rating indicate a research need but perhaps a lack of funds or knowledge to fulfill the need.

Prevention of logging mishaps instead of rehabilitation was a common concern throughout the workshop. The needs listed are all necessary considerations for the establishment of guidelines for "optimum

watershed management." The ultimate goal of watershed management and protection should be to maximize social benefit from our watershed resources; and without adequate information, land planners and managers cannot accomplish this goal.

SUMMARY

Increasing emphasis is being placed on meeting the requirements of Forest Practices Acts (California, Oregon, and Washington, in particular), and in the future, more environmental impact statements of the Environmental Protection Agency-type will be required. Judging from published research, adequate impact statements obviously will be difficult to formulate. Consequently, regulations will continue to be conservative, with an increasing amount of field supervision required to monitor whatever environmental impacts are predicted.

Research is at a point of requiring precise information on population dynamics of fishes and continued research on physical measurements of the environment. This will lead to more case history research which will ultimately lead to more precise and meaningful guidelines for management.

Meanwhile, general survey-type research such as that of Calhoun (*201*), Calhoun and Seeley (*202*), and Fisk et al. (*208*) of California streams, has had its day; and the logger, the researcher, and the management agencies must realize that there are no finite answers, no finite guidelines, and perhaps never will be. This, however, should intensify research and concern rather than relax it, for the formulation and application of theory or scientific laws that are open-ended are sometimes difficult but necessary. This is particularly difficult for the land user to accept, but it is a fact of life and a state-of-the-art for some time to come. On the other hand, the fisheries resource manager has difficulty accepting that which is becoming obvious--i.e., logging (even clearcutting) can be performed without radical damage, in fact, the changes can be so subtle as to defy measurement and at times may, indeed, be beneficial. An obvious area of needed research is the degree to which a stream should be cleared, manipulated, or even altered for improvement. In conclusion, there will never by a "once-and-for-all" answer to land use-fisheries problems, but we must continue answering questions to provide for optimal watershed management.

ANNOTATED BIBLIOGRAPHY

INTRODUCTION

The following annotated bibliography documents publications on effects of logging on fish of the Western United States and Canada, with a few other selected references also included. Whenever possible, the abstract or summary written by the author was used for the annotation.

The titles are arranged alphabetically by authors and chronologically under each author's name. Author and subject indexes are included.

EROSION AND SEDIMENTATION

(1) Aitken, W. W.
1936. The relation of soil erosion to stream improvement and fish life. J. For. 34(12):1059-1061.

The author notes that gradual changes in stream environment caused by erosion can bring about corresponding changes in fish fauna. Without erosion control, stream improvement devices are of little value since they cannot eliminate turbidity, siltation, and other conditions resulting from erosion that are deleterious to fish life.

(2) Anderson, H. W.
1957. Relating sediment yield to watershed variables. Trans. Am. Geophys. Union 38(6):921-924.

"The yield of sediment from watersheds depends upon three sets of variables: (1) inherent watershed characteristics such as geology and topography; (2) land use, condition of vegetation, and management and protective measures; and (3) nature of storms and streamflow which produce and transport sediment. Measured quantities of yield also depend on the sediment measuring device and on which fraction of total sediment yield is measured. The sources of variation in sediment yield between and within watersheds can be evaluated by study of the yield from many watersheds which have wide differences in variables affecting sediment yields. Such studies are useful to determine and evaluate the principal sources of sediment, to evaluate the probable effects of conservation programs on yield, and to provide criteria for design of reservoirs and channels. This paper summarizes some recent studies in which multiple regression analysis was used in relating sediment yield to watershed variables. The studies are discussed in the light of methods of selecting watersheds, data, variables, and functions; and the effects of neglected variables, errors in variables, and exclusion of nonsignificant variables."

(3) Anderson, Henry W.
1954. Suspended sediment discharge as related to streamflow, topography, soil and land use. Trans. Am. Geophys. Union 35(2):268-281.

"The results of suspended-sediment sampling were used to obtain average annual suspended sediment discharge from 29 watersheds of western Oregon by relating sediment-sampling results to streamflow and by using streamflow frequencies. The values of average suspended sediment thus obtained were related by regression analysis to average watershed values of two streamflow variables, two topographic variables, two soil variables, and one channel bank variable. The soil variables were functions of particle size and aggregation determined by analyzing samples of the surface soil taken at standardized locations in the major geologic types. The other variables were functions of data published in maps and other secondary sources. The regression results were used (1) to construct a map of

the sediment producing potential of lands in western Oregon under average land use conditions; (2) to estimate how the actual production of sediment would differ from the potential with deviation of land use from average; and (3) to distribute present sediment production to the three major source areas: forest land, agricultural land, and channel banks of the main river."

(4) Anderson, Henry W.
1962. Current research on sedimentation and erosion in California wildlands. Rep. Publ., Assoc. Int. Hydrol. Sci., Gentbrugge 59:173-182.

The effects of fire and logging on erosion and sedimentation were studied in the Sierra Nevada Coast Range and San Gabriel Mountains. No study of buffer zones was made, nor was their relation to logging discussed.

(5) Anderson, Henry W.
1971. Relative contributions of sediment from source areas, and transport processes. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 55-63. Oreg. State Univ., Corvallis.

"The paper reports new findings, offers a reanalysis of older studies, and summarizes pertinent results in the literature. Past land use, forest fires, road building, 'poor logging,' and conversion of steep lands to grass have increased sediment discharge by factors ranging from 1.24 to more than 4. Projected future use is expected to increase sediment production by a factor of 4, with 80 percent associated with roads and 20 percent with logging. Major floods have increased subsequent turbidity of streamflow by a factor of 2. The increases were greater in logged areas of watersheds where roads were next to streams and landings were in draws than in undisturbed watersheds. Most landslides were associated with road development, next most with logged areas, and least with undisturbed forest area. The number of turbid days in streamflow varied by a factor of 2.34 with differences in silt plus clay content of soils, by 8.55 with differences in erodibility, and by 4.3 with the percent of gravel. Further, these soil characteristics were predictable from geologic rock types. In a sample calculation, 89 percent of channel bedload became suspended load enroute downstream. Soil creep contributed 15 percent to total sediment discharge from watersheds; channel bank erosion contributed 54 to 55 percent."

(6) Anderson, Henry W., and James R. Wallis
1963. Some interpretations of sediment sources and causes, Pacific coast basins in Oregon and California. U.S. Dep. Agric. Misc. Publ. 970:22-30.

Sediment discharges associated with specific measures of meteorological potential, topographic potential, soil erodibility, and land use and condition from studies of sedimentation in coast basins of western Oregon and California were compared. Results obtained by combining the

effects of all the various sediment potentials can be used to delineate areas where caution in management may be needed and to measure the effectiveness of certain types of land management.

(7) Bachman, Roger Werner
1958. The ecology of four northern Idaho trout streams with reference to the influence of forest road construction. 97 p. M.S. thesis, Univ. Idaho, Moscow.

Physicochemical and biological measurements of four trout streams, one of which was being logged, were studied. Turbidity was found to increase during rapid runoff from storms or snowmelt. Sedimentation increased in both riffles and pools. Water temperatures, volume of flow, and water chemistry showed no change from the previous year. The relocation of stream channels away from road fills appeared to reduce the amount of eroded material entering the stream.

(8) Bishop, Daniel M., and Mervin E. Stevens
1964. Landslides on logged areas in southeastern Alaska. USDA For. Serv. Res. Pap. NOR-1, 18 p. North. For. Exp. Stn., Juneau, Alaska.

"Recent large-scale clearcut logging of timber in southeast Alaska has accelerated debris avalanches and flows on steep slopes during heavy rainfall. Characteristics and possible mechanisms for these disturbances include:

"1. Flows are more frequent within the V-notch side-drainages than on the smoother glacial valley walls. This may be attributed to V-notch channel downcutting producing oversteepened slopes.

"2. Flows or avalanches usually slide on relatively smooth, wet planes oriented parallel to the slope when this plane is composed of such materials as glacial till, iron-organic layered material, metamorphosed sediments, or diorite. Such planes are resistant to downward water passage; hence, moisture builds up immediately above this layer.

"3. Limited evidence leads to the assumption that southeast Alaskan flow-prone soils are usually cohesionless. If this is true, then soil pore pressure phenomena may not reasonably be expected.

"4. A greater addition of water weight to the soil mantle through rainfall is not a likely stimulus for increased flows after logging. Research in other areas indicates that water infiltration rate into the soil is reduced by clear-cut logging, and that loss of soil organic matter as a result of logging reduces water-holding capacity. If these findings are applicable to southeast Alaska, then less weight from soil water might be expected.

"5. Weight loss by timber removal probably has no direct net effect on the likelihood of shearing since decrease of shear stress with unloading is equal to shear strength reduction.

"6. Loss of timber weight may reduce shear strength in soil immediately under the tree root systems. This action might result from 'decompaction' of zones of soil earlier compacted by the weight of the tree.

"7. Loss of root systems as a strength builder-maintainer in the soil mantle may be an important factor in accelerating flows after logging. This may reflect the destruction of inter-connected root systems by high-lead skid-roads. It may also reflect death and gradual deterioration of root systems after clear cutting. The time lag in slide activity after logging supports this view.

"8. Debris in the bottoms of steep ravines aggravates stability conditions. Logs and stumps on side slopes contribute to such instability by rolling or sliding into the channel. The process follows a pattern--debris accumulates in the ravine bottoms and this is followed periodically by sweeping torrent-flows.

"9. Slopes of 34° (67 percent) or more are highly susceptible to failure when conventional downhill high-lead logging is used."

(9) Brown, George W., and James T. Krygier
1971. Clear-cut logging and sediment production in the Oregon Coast Range. Water Resour. Res. 7(5):1189-1198.

"The impact of road construction, two patterns of clear-cut logging, and controlled slash burning on the suspended sediment yield and concentration from three small watersheds in the Oregon Coast Range was studied for 11 years. Sediment production was doubled after road construction but before logging in one watershed and was tripled after burning and clear-cutting of another watershed. Felling and yarding did not produce statistically significant changes in sediment concentration. Variation in the relation between sediment concentration and water discharge on small undisturbed streams was large. Conclusions about the significance of all but very large changes in sediment concentration are limited because of annual variation for a given watershed, variation between watersheds, and variation with stage at a given point."

(10) Bullard, W. E., Jr.
1965. Role of watershed management in the maintenance of suitable environments for aquatic life. *In* Clarence M. Tarzwell [ed.], Transactions 3rd seminar on biological problems in water pollution. U.S. Public Health Serv. Publ. 999-WP-25, p. 265-269. Robert A. Taft Sanit. Eng. Cent., Cincinnati, Ohio.

"Increased sedimentation of streams seems to be the most obvious effect of land use practices on the aquatic habitat. The addition of finer

particles on the bottom gravels reduces the niches where many benthic organisms live. Perhaps the direct effects on eggs are among the most important. There is a smothering effect from silt coatings and a decreased permeability of the bottom gravels reducing the flow of water over the eggs. The turbidity resulting from the increase in suspended particles also reduces the light penetration and photosynthetic rate.

"Not all sedimentation is a result of obvious operations such as mining and cultivation. Instances are on record in which the activity of ducks has reduced fish egg survival. Perhaps the trampling of stream banks by cattle may be far more important than is commonly recognized. Changes in the stream bank brought about by cattle or man-made channel changes may produce a cycle of changes which may be carried clear to the mouth of the stream. Usually, these changes are not desirable.

"The feeling among the discussants seemed to be that, ideally for fish production, partial tree cover of the banks, something less than complete bank stabilization, and an increase in rainfall infiltration of the soil are all desirable goals along with reduction in siltation and turbidity. However, the attainment of such goals may affect the stream flow patterns and reduce the total amount of water reaching the stream. In more arid areas, grasses are more desirable than trees because they achieve stabilization of soil but do not lose as much water through transpiration.

"In any case, the optimum conditions for fish production will have to be sacrificed in many instances for multiple uses of the surface waters. However, the general feeling was that many improvements could be made that would improve the waters for fish production and still incorporate multiple use."

(11) Bullard, William
1959. Watershed management-grazing, deforestation and road building. *In* E. F. Eldridge and J. N. Wilson [eds.], Proceedings 5th symposium--Pacific Northwest on siltation--its source and effects on aquatic environment, p. 27-31. U.S. Dep. Health, Educ. & Welfare, Portland, Oreg.

Sources of siltation and methods to control and correct it are discussed. An outline of factors to consider in watershed management for the control of erosion and subsequent siltation of streams is presented.

(12) Burns, James W.
1970. Spawning bed sedimentation studies in northern California streams. Calif. Fish & Game 56(4):253-270.

"Changes in the size composition of spawning bed materials in six coastal streams were monitored for 3 years to determine the effects of logging on the habitat of silver salmon (*Oncorhynchus kisutch*) and

trout (*Salmo gairdnerii gairdnerii* and *S. clarkii clarkii*). Four test streams were sampled before, during and after logging. Two streams in unlogged watersheds and the undisturbed upstream section of one test stream served as controls. A variety of stream types in second-growth and old-growth forests was selected for observation.

"Spawning bed composition in the four test streams changed after logging, roughly in proportion to the amount of streambank disturbance. The heaviest sedimentation occurred when bulldozers operated in narrow stream channels having pebble bottoms. In a larger stream with a cobble and boulder bottom, bulldozer operations in the channel did not increase sedimentation greatly. Sustained logging and road construction kept sediment levels high in one stream for several years. Sedimentation was greatest during periods of road construction near streams and removal of debris from streams, confirming the need for special measures to minimize erosion during such operations. Control streams changed little in spawning bed composition during the 3 years."

(13) California Resource Agency
1970. Task force findings and recommendations on sediment problems in the Trinity River near Lewiston and a summary of the watershed investigation. A Report to the Secretary for Resources, 32 p. Sacramento, Calif.

Estimated amounts of sediment and transport capacities show that before logging and dam construction the Trinity River was capable of transporting bedload sediment. After logging, the river's transport capacity and sediment discharge were approximately equal; hence, the river was still able to flush the added sediment from logging operations. After dam construction, the sediment transport capacity of the river was reduced to such an extent that sediment in the channel quickly built up. The result has been the deterioration of adequate spawning grounds.

(14) Cooper, A. C.
1965. The effect of transported stream sediments on the survival of sockeye and pink salmon eggs and alevin. Int. Pac. Salmon Fish. Comm. Bull. 18, 71 p.

"Results are presented of studies made to assess quantitatively the effects of sediment deposition upon and within salmon spawning beds on the survival of salmon eggs and alevin. Methods of determining the size of bed load materials that may be expected on a given portion of a stream bed are presented. Spawning gravel permeability is defined in terms of particle size grading, particle shape and gravel porosity. The velocity of fluid flow through the gravel is quantitatively related to the gravel permeability and the hydraulic gradient. Deposition of sediment either on the gravel surface or within the gravel is shown to reduce gravel permeability with consequent reduction in fluid flow and reduction in rate of survival of salmon eggs and alevin deposited in the gravel.

Formulae are developed which relate time and silt size and concentration to the effect on gravel permeability, and examples of the consequent effect on survival of salmon eggs and alevin are presented. The results of the studies show the importance of preventing deposition of sediments on or within a salmon spawning bed."

(15) Cordone, Almo J., and Don W. Kelley
1961. The influences of inorganic sediment on the aquatic life of streams. Calif. Fish & Game 47(2):189-228.

The effects of inorganic sediment on aquatic life in streams were discussed. The report covered the following subjects: direct effect of sediment upon fishes; influence of sediment upon eggs, alevins, bottom organisms, aquatic plants, chemical and physical characteristics of aquatic life, and fish habitat and population; and sediment standards and research.

(16) Cordone, Almo J., and Steve Pennoyer
1960. Notes on silt pollution in the Truckee River drainage, Nevada and Placer Counties. Calif. Fish & Game, Reg. 2, Inland Fish. Admin. Rep. 60-14, 25 p. [Processed.]

Silt from a gravel washing plant drastically reduced the populations of bottom organisms immediately below the outfall and as far as 10 miles downstream at Cold Creek and Truckee River, California.

(17) Dellberg, Robert A., and John N. Taylor
1962. Erosion control on timberland at harvest. J. Soil & Water Conserv. 17(4):177-178.

Methods of erosion control were studied in a limited logging operation in Mendocino County, California.

(18) Dyrness, C. T.
1966. Erodibility and erosion potential of forest watersheds. *In* William E. Sopper and Howard W. Lull [eds.], Forest hyrology, p. 599-611. Proc. Natl. Sci. Found. Adv. Sci. New York: Pergamon Press.

"This paper reviews a portion of the literature dealing with forest soil erosion and erodibility. Two main aspects to forest soil erodibility are generally stressed--resistance of soil particles to detachment and transport, and soil infiltration rate. Resistance to detachment and transport is controlled to a large extent by amounts of water-stable aggregation. Several erodibility indices, utilizing different measurements of surface soil aggregation, have been developed. Factors strongly influencing these erodibility indices include soil parent material, organic matter content, climatic conditions, and soil

chemical properties. Many studies have shown that infiltration rate decreases considerably when plant and litter cover is removed, thus exposing the mineral soil surface to the destructive action of rain.

"Some accelerated erosion is generally a necessary consequence of road construction and logging in forest watersheds. Primary causes are reported to be exposure of bare mineral soil and surface soil compaction. Both controlled burning and wildfires in forested areas are often followed by increased rates of surface erosion. Although severe burning may cause increased erodibility, light burning apparently has little effect on soil properties. A change of primary importance caused by fire is removal of protective vegetation and litter.

"Research needs in this field include development of methods for quantitatively estimating forest soil erosion potential and establishment of erosion tolerances for individual forest watersheds."

(19) Dyrness, C. T.
1967. Mass soil movements in the H. J. Andrews Experimental Forest. USDA For. Serv. Res. Pap. PNW-42, 12 p., illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"Analyzes 47 mass movement events resulting from severe storms during the winter of 1964-65. Earthflow and channel scouring events were the most common. About 72 percent of the mass movements occurred in connection with roads and 17 percent in logged areas. Over 94 percent of the events occurred in areas of tuff and/or breccia bedrock which occupy only 37 percent of the total area."

(20) Dyrness, C. T.
1967. Soil surface conditions following skyline logging. USDA For. Serv. Res. Note PNW-55, 8 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

There was very little difference in yarding-caused disturbance when skyline and high-lead logging were compared. It was therefore concluded that the main advantage of skyline logging is that it requires less road construction. Skyline logging was previously proven by V. W. Binkley to require one-third as many road requirements as high-lead logging. This reduction is extremely important in reducing stream source sediments which are a proven major source of sediment in streams. Thus, the use of skyline logging in steep, mountainous areas to reduce stream sedimentation deserves serious consideration.

(21) Dyrness, C. T.
1970. Stabilization of newly constructed road backslopes by mulch and grass-legume treatments. USDA For. Serv. Res. Note PNW-123, 5 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"Amounts of soil loss from an unprotected newly constructed backslope were two to four times greater than loss from a comparable slope 5 years after construction. Of six roadside treatments studied, the two showing consistently large amounts of soil loss during the first critical rainy period were the only ones without a straw mulch covering."

(22) Dyrness, C. T., C. T. Youngberg, and Robert H. Ruth
1957. Some effects of logging and slash burning on physical soil properties in the Corvallis watershed. USDA For. Serv. Pac. Northwest For. & Range Exp. Stn. Res. Pap. 19, 15 p. Portland, Oreg.

"Physical soil properties measured in this study did not differ significantly among 4 of the 5 surface conditions sampled. Only in the severely burned condition was there found a consistent and significant departure, indicating that intense heat altered the character of the surface soil. Physical properties of soil in undisturbed, disturbed-unburned, and lightly burned portions of the clearcuts remained closely similar to those under adjacent timber stands.

"This study can be considered only a partial evaluation of the effects of logging and slash burning on soils in the Douglas-fir region. Soil tests were not intended to be a complete investigation of the soil changes which occur. Furthermore, only three types of soil were examined. These are known to occur throughout the Coast and Cascade Ranges in Oregon and Washington, so, while limited in scope, results of this study are applicable over a substantial part of the Douglas-fir region. Still, to assess fully the effect of logging and slash burning, other soils associated with the Douglas-fir type will need to be sampled and subjected to comprehensive tests."

(23) Ellis, M. M.
1936. Erosion silt as a factor in aquatic environments. Ecology 17:29-42.

Effects of silt on the aquatic environment are discussed. Erosion silt alters the environment by (1) screening out light, (2) changing heat radiation, (3) covering the stream bottom, and (4) retaining organic material.

(24) Fredricksen [Fredriksen], R. L.
1965. Sedimentation after logging road construction in a small western Oregon watershed. U.S. Dep. Agric. Misc. Publ. 970: 56-59, illus.

"During the summer of 1959, 1.65 miles of logging road were constructed in a 250-acre forested watershed that rises 2,000 feet in a distance of 1 mile. This study evaluates the change in sedimentation subsequent to road construction. Runoff from undisturbed watersheds in this area remains clear during the summer low-flow months and reaches concentrations of 100 parts per million during winter storm peaks. Runoff from the first rainstorms after road construction carried 250 times the concentration carried in an adjacent undisturbed watershed. Two months after construction, sediment had diminished to levels slightly above those measured before construction. Sediment concentrations for the subsequent 2-year period were significantly different from preroad levels. In about 10 percent of the samples, sediment concentrations were far in excess of predicted values, indicating a streambank failure or mass soil movement. Annual bedload volume the first year after construction was significantly greater than the expected yield, but the actual increase was small. A trend toward normalcy was evident the second year."

(25) Fredriksen, R. L.
1970. Erosion and sedimentation following road construction and timber harvest on unstable soils in three small western Oregon watersheds. USDA For. Serv. Res. Pap. PNW-104, 15 p., illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"In two steep headwater drainages, landslides were the predominant source of increased sedimentation of streams following timber harvest. Patchcut logging with forest roads increased sedimentation compared with a control by more than 100 times over a 9-year period. Landslide erosion was greatest where roads crossed high gradient stream channels. In an adjacent clearcut watershed with no roads, sedimentation increased three times that of the control."

(26) Gangmark, Harold A., and Richard G. Bakkala
1960. A comparative study of unstable and stable (artificial channel) spawning streams for incubating king salmon at Mill Creek. Calif. Fish & Game 46:151-164.

"With the knowledge that fast stream run-off was significant in the mortality of spawn, effort was directed toward finding exactly how severe runoff caused these losses. It was determined that mortalities were caused by both direct and indirect factors. Direct losses of spawn was due primarily to erosion of the streambed by high velocities of water. Information as to the fate of spawn washed out is not available, but it is reasonable to assume that once the eggs are washed

from the protecting gravel bed out into the stream of violent water flow and shifting gravel, their chance of survival is low. Indirect losses of spawn occurred from a series of events of diverse and complex nature involving loss of spawning gravel and erosion of soil. Another series of events causing indirect loss of salmon spawn starts with soil erosion that clogs the redd. This blockage leads to: inadequate oxygen and poor delivery of oxygen to the eggs and poor cleansing of metabolic waste products."

(27) Hansen, Edward A.
1971. Sediment in a Michigan trout stream, its source, movement, and some effects on fish habitat. USDA For. Serv. Res. Pap. NC-59, 14 p. North Cent. For. Exp. Stn., St. Paul, Minn.

"A sediment budget was constructed from 3-years of measurements on a pool and riffle stream. Total sediment load increased five times along a 26-mile length of stream; most sediment came from 204 eroding banks. Three-fourths of the total sediment load was sand size. The area of streambed covered with sand decreased downstream, indicating that the transporting capacity of the stream exceeded sediment supply. Complete streambank stabilization would reduce the sediment load by about half and probably result in streambed composition changes beneficial to trout."

(28) Haupt, Harold F., and W. Joe Kidd, Jr.
1965. Good logging practices reduce sedimentation in central Idaho. J. For. 63(9):664-670.

"From the inception of a study of cutting ponderosa pine on 16 small watersheds in the Boise Basin Experimental Forest, sedimentation was checked reasonably well because of careful advance planning, close supervision of logging, and application of intensive measures for controlling erosion promptly after harvest. Sediment that reached the stream channels originated primarily on haul roads. Proximity of a road to a stream affected the frequency with which sediment flows reached that stream. Sediment reached channel bottoms through undisturbed buffer strips averaging 8 feet wide, but did not reach them if the strips were more than 30 feet wide. After 3 years, movement of sediment 'en route' had almost halted."

(29) Hollis, Edgar H., Joseph G. Boone, Charles R. De Rose, and George J. Murphy. 1964. A literature review of the effects of turbidity and siltation on aquatic life. 26 p. Staff Rep., Dep. Chesapeake Bay Aff. Annapolis, Md.

The detrimental effects of turbidity and siltation upon aquatic life are reviewed. The report contains a fairly extensive bibliography.

(30) Hornbeck, J. W., and K. G. Reinhart
1964. Water quality and soil erosion as affected by logging in steep terrain. J. Soil & Water Conserv. 19(1):23-27.

"The influence of different forestry practices on streamflow has been investigated since 1951 on 5 forested watersheds, 38 to 96 acres in area, on the Fernow Experimental Forest in the mountains of West Virginia. The effects of cutting and logging practices on water quality are reported in this article.

"Practices ranged from a commercial clearcutting without regard to water values or the future value of the property to an intensive selection cutting with useful planning and careful logging. The experiment demonstrated that excessive damage to water quality can be avoided even when logging on steep terrain. Measured maximum turbidities of streams were 56,000 ppm on the commercial clearcut area and only 25 ppm on the intensive selection cut watershed. Most of the damage to water quality occurred during and immediately after logging.

"Recommended forestry practices discussed include: planning of the logging operation; proper location, drainage, and grade of skidroads; and timely completion of the operation in any specific area. In most respects, practices recommended for watershed protection also contribute to the overall efficiency of the logging operation."

(31) Kelley, Don
1962. Sedimentation helps destroy trout streams. Outdoor Calif. 23(3):4, 5, 10-11.

The effects of sediment on the basic needs of a trout population--its food, shelter, and a place to reproduce--are discussed.

(32) Koski, K V.
1972. Effects of sediment on fish resources. Presentation--Wash. State Dep. Nat. Resour. Manage. Semin., April 18-20, 1972, 36 p. [Mimeogr.]

The effects of sediment on aquatic organisms are discussed. Specific areas of discussion are: (1) freshwater requirements of salmonids, (2) general effects of sediment on fish, (3) effects of sediment on the reproduction of salmonids, (4) the harmful threshold of sediment, (5) effects of sediment on natural populations of fish, and (6) effects of logging on sediment production. An extensive bibliography is included.

(33) Larse, Robert W.
1971. Prevention and control of erosion and stream sedimentation from forest roads. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 76-83. Oreg. State Univ., Corvallis.

"To minimize erosion and resultant stream sedimentation, prevention and control measures must be given consideration in every aspect of road planning, design, construction and maintenance. In mountainous terrain the forest land manager must establish specific objectives and prescriptions to guide road network construction and utilize the combined professional skills of the forester, engineer, geologist, biologist, and others to set standards for the protection of watershed values, identify alternatives, and offer solutions to specific problems.

"The decision to road an area should only be made after the resource-serving benefits have been carefully weighed against the cost and effect of roading on the watershed. The decision not-to-road and to accept other alternatives for land-use management must be strongly considered when the probability of lasting damage to soil, water, and other ecological values is recognized."

(34) Lull, Howard W., and K. G. Reinhart
1965. Logging and erosion on rough terrain in the east. U.S. Dep. Agric. Misc. Publ. 970:43-47.

"Most of the erosion from logging roads occurred during the logging operation. This suggests:

"1. That the operation in any one area should not be prolonged, but should be completed as soon as possible.

"2. That more attention should be paid to preventing erosion during the operation. It is not enough to limit erosion control measures to after-logging care. Perhaps the most practical measure is to cut and maintain broad-based outsloped drainage dips across skidroads. This is not always easy, and the idea will often be resisted by loggers.

"This study points up again the fact that erosion from only a fraction of the logging area can pollute a lot of water. Hoover... has pointed out that a short stretch of logging road can produce much more sediment than occasional patches of steep land in cultivated crops. The forester who might not permit clearing a piece of forested municipal watershed for a row crop because of the erosion hazard should feel just as much concern over the location of logging roads.

"Finally, observations in many areas indicate that continuously used permanent road systems in the forest can create serious water-quality problems. Standards for constructing and maintaining such roads should be even higher than for logging roads that are used for only short periods of time."

(35) McCrimmon, H. R.
1954. Stream studies on planted Atlantic salmon. J. Fish. Res. Board Can. 11(4):362-403. [Taken from Cordone (*148*).]

"This is an evaluation of the survival and distribution of Atlantic salmon fry planted in a small stream tributary to Lake Ontario. Included is an examination of some of the factors affecting the survival of these fry. The influence of sedimentation on survival was studied in detail.

"When the correlation of salmon survival with brook trout predation was analyzed further, it was found that the amount of available shelter which the stream offered the fry was most important in determining the survival or death of the planted fish.

"It has been shown in a previous section that the shelter offered by shallow gravelly riffle area was the only satisfactory habitat for the survival of planted fry in all streams. In the general description of the relative extent of sedimentation over the stream system, the criterion employed was the degree to which these gravelly riffle areas had become sedimented. Areas typed as 'unsedimented' were those in which the spaces around the gravel and rubble were not filled in by sediment and hence offered the shelter required by the planted fry. The degree of bottom sedimentation played an important part in influencing the survival and distribution of the planted salmon.

. . . .

"It was shown that the survival of the small fry in the pools was low, largely because the absence of suitable shelter for the young salmon resulted in predation by certain species of fish. This lack of shelter was directly caused by the deposition of sediment in the pools sufficiently great to cover generally the gravel and rubble, and fill the spaces around stones, boulders, logs and the like, to an extent that they could not be utilized by the fry.

"Survival studies showed an average percentage survival for underyearling salmon. . .of 23.4 percent in comparison to a survival of only 2.2 percent in an area in which riffle sedimentation was the heaviest observed in the part of the stream system planted with salmon."

(36) McRorey, R. P., N. F. Meadowcroft, and C. J. Kraebel
1954. A guide to erosion reduction on National Forest timber sale areas. USDA For. Serv. Calif. Reg. For. & Range Exp. Stn., 78 p. Berkeley, Calif.

Over one-half the manual concerns the construction and maintenance of logging roads.

Leaving an uncut, protective strip along streams is recommended; however, no minimum width is mentioned.

(37) Marcuson, Pat
1968. Stream sediment investigation. Mont. Dep. Fish & Game, South Cent. Mont. Fish. Study. Job Completion Rep. Proj. F-20-R-13, 10 p.

"This report...compares current data with data collected before completion of three stream habitat improvement projects on Bluewater Creek. Maximum and minimum water temperatures, mean monthly discharge and mean sediment data are tabled and discussed for the report period.

"Mean monthly sediment concentrations and loads were lowest at Station 1 and progressively increased downstream. Average suspended sediment load has been reduced by 1.9 tons/day or 32% at Station 2, 14.0 tons/day or 52% at Station 3 and 10.5 tons/day or 44% at Station 4 following the three streambank improvement projects located near Station 2.

"Trout composition at all stations on Bluewater Creek represented 37% of the fish sampled in 1968 compared to 13% in 1963 prior to habitat improvement. Trout:rough fish ratios were not appreciably altered following a 32% reduction in sediment load at Station 2. Corresponding with a 52% reduction in sediment load at Station 3, there has been a change in weight ratios of trout:rough fish from 39:61 in 1963 to 63:37 in 1967 and 78:22 in 1968. At Station 4 the trout:rough fish weight ratio has changed from 12:88 in 1963 to 34:66 in 1967 to 51:49 in 1968."

(38) Megahan, W. F., and W. J. Kidd
1972. Effects of logging and logging roads on erosion and sediment deposition from steep terrain. J. For. 70(3): 136-141.

"Erosion plots and sediment dams were used to evaluate the effects of jammer and skyline logging systems on erosion and sedimentation in steep, ephemeral drainages in the Idaho Batholith of central Idaho. Five-year plot data indicated that no difference in erosion resulted from the two skidding systems as applied in the study. Sediment dam data obtained concurrently showed that the logging operations

alone (excluding roads) increased sediment production by a factor of about 0.6 over the natural sedimentation rate. Roads associated with the jammer logging system increased sediment production an average of about 750 times over the natural rate for the six-year period following construction."

(39) Miner, Norman H.
1968. Natural filtering of suspended soil by a stream at low flow. USDA For. Serv. Res. Note PNW-88, 4 p. illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"During road construction, soil that is added to a stream by tractors crossing during low flow is temporarily 'filtered' out before it travels far. Five-gallon samples were taken at 150, 300, 600, and 1,200 feet downstream from a road crossing, with sodium fluorescein dye used as a tracer. Suspended particle concentration was reduced from 1,055 p.p.m. at 150 feet below the road to 108 p.p.m. at 1,200 feet. The The 'filtering' action is a combination of settling of larger particles and dilution of sediment-laden water. This filtration is temporary, and deposited soil will tend to be flushed downstream during high flows and may cause channel erosion or other damage."

(40) Packer, Paul E., and George F. Christensen
[n.d.] Guides for controlling sediment from secondary logging roads. USDA For. Serv. Intermt. For. & Range Exp. Stn. and North. Reg., 42 p. Missoula, Mont.

"Measurements and observations indicate that as much as 90 percent of the sediment produced by erosion on timber sale areas is from roads. Research and experience show that damage to soil and water can be largely prevented by conscientious application of specific guides for design, location, construction, and maintenance of forest roads.

"This handbook contains guides to help in location and design of secondary logging roads and installation of water control structures that will reduce erosion and prevent sediment from entering streams."

(41) Patric, J. H., and D. N. Swanston
1968. Hydrology of a slide-prone glacial till soil in southeast Alaska. J. For. 66(1):62-66.

"Heavy irrigation caused no surface runoff, erosion, or debris avalanches on well-drained Karta soil, a tentative series producing much of the commercial timber in southeast Alaska. Interpreting measured rainfall, streamflow, and piezometric head in terms of Darcy's equation showed how this slide-prone soil accommodates large amounts of water. About 2/3 of the water applied drained laterally through permeable surface layers to a stream adjacent to the study area. The remaining 1/3 presumably drained deeply into highly fractured bedrock. Less permeable

soil, less fractured bedrock, or longer irrigated slopes probably would have caused saturated soil under heavy watering. It appears that Karta soil must be saturated to cause debris avalanches, a condition which may occur naturally when much larger areas are wetted by much smaller rainfall."

(42) Peters, John C.
1965. The effects of stream sedimentation on trout embryo survival. *In* Clarence M. Tarzwell [ed.], Transactions 3rd seminar on biological problems in water pollution. U.S. Public Health Serv. Publ. 999-WP-25, p. 275-279. Robert A. Taft Sanit. Eng. Cent., Cincinnati, Ohio.

"Bluewater Creek, during the study period, was characterized as a stream with little fluctuation in discharge. There was a progressive downstream increase in sediment concentrations at the five sampling areas in the stream. Man-made redds filled with 3/8-inch gravel chips were placed in the vicinity of each sediment-sampling station. Each redd, at the start of the study, had almost identically large intragravel dissolved-oxygen concentrations and intragravel apparent velocities. The intragravel dissolved-oxygen concentration rate and apparent velocity decreased progressively downstream in relation to the progressive downstream increase in sediment concentration. Accompanying the progressive downstream decrease in intragravel dissolved-oxygen concentrations and intragravel apparent velocities was a progressive increase in trout embryo mortality.

"Sediment passing a given area of a stream can greatly affect trout embryo survival. Small sediment concentrations with small fluctuations in discharge in a stable streambed environment indicate a stream area with a potential for good trout embryo survival."

(43) Phillips, Robert W.
1971. Effects of sediment on the gravel environment and fish production. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 64-74. Oreg. State Univ., Corvallis.

"Research in the field is summarized. Sediment influences fish in several ways. In suspension, (1) it blocks the transmission of light, reducing algae production, and (2) it damages the gill membranes, causing death where concentrations are high and exposure is prolonged. When sediment settles on the gravel beds, it is harmful in the following ways: (1) It fills the interstices reducing interchange between surface waters and waters within the gravel bed. This reduces the supply of dissolved oxygen to the egg, and interferes with the removal of metabolites (carbon dioxide and ammonia). (2) Sediment also forms a barrier to fry emergence by blocking the route of egress. (3) Low dissolved oxygen and the physical barrier effect of sediment appear to be

additive in reducing survival. (4) Survival after fry emergence is impaired because of a loss of escape cover and a reduction of aquatic organisms that are food for fish. Examples are cited showing that pink and chum salmon survival is inversely related to the amount of sediment in gravel beds."

(44) Platts, William S.
1970. The effects of logging and road construction on the aquatic habitat of the South Fork Salmon River, Idaho. [Abstract.] USDA For. Serv., Zone Fish. Biol., 4 p.

The harvest and resulting road construction of 325 million board feet of timber removed from 7 percent of the South Fork Salmon River caused aquatic habitat degradation. To determine the aquatic habitat conditions, data were collected from 325 randomly located stream transects, 670 streambank points, 90 additional stream transects in spawning areas, 155 streambed core samples, and 80 additional streambed core samples in major spawning areas. Results showed the South Fork Salmon River to be a heavily sedimented stream, especially in the salmonid spawning areas. The studies showed that both streambed surface and depth sediment content were very high. The salmon redds contained slightly less fine materials than the overall spawning areas but were not capable of eliminating required amounts of sediment from egg incubation areas which would result in good permeability.

A debris basin was effective in improving the aquatic habitat in the stream immediately below the basin during low and normal waterflows, but it was detrimental to downstream habitat during its initial construction and early existence.

(45) Rice, R. M., and J. R. Wallis
1962. How a logging operation can affect streamflow. For. Ind. 89(11):38-40.

Effects of logging on streamflow and sedimentation in Castle Creek, a high Sierra watershed, were studied. The results pinpoint the fact that even though the total disturbance of the Castle Creek watershed was not great, roads and landings created a large source of sediment.

(46) Saunders, J. W., and M. W. Smith
1965. Changes in a stream population of trout associated with increased silt. J. Fish. Res. Board. Can. 22(2):395-404.

"Low standing crops of brook trout, *Salvelinus fontinalis*, were closely associated with silting in Ellerslie Brook, Prince Edward Island, and appeared to result from the destruction of hiding places. Spawning was also curtailed by silting. Following scouring, trout stocks soon increased. The remarkable adaptability of trout to silting, in a habitat with favourable flow and water temperature, was illustrated."

(47) Shapley, S. Philip, and Daniel M. Bishop
1965. Sedimentation in a salmon stream. J. Fish. Res. Board Can. 22(4):919-928.

"Sediment was artificially added to a small southeastern Alaskan salmon stream. Observations in sediment and control riffles indicate that the amount of sediment settling to the stream bottom decreases exponentially with distance downstream. The dissolved oxygen content of intragravel stream water remained high in sedimented riffles. The added sediment was removed from streambed gravels by fall freshets and floods."

(48) Sheridan, William L.
1968. Land use and sediment. *In* Richard T. Myren [ed.], Logging and salmon, p. 62-79. Proc. Forum Am. Inst. Fish. Res. Biol., Alaska Dist., Juneau, Alaska.

"Of the characteristics that logging and road construction could influence, sediment levels in spawning gravels may be one of the most important. It has been established that sediment decreases permeability of spawning gravels, interferes with interchange of water between the gravels and the surface stream, decreases the velocity of water bathing salmon embryos, and when abundant, prevents alevins from emerging.

"Although there is little doubt that logging and road construction contribute some sediment to salmon streams, there is no evidence to show that these activities, when conducted according to protective clauses included in all timber sale contracts, have damaged the salmon resource in southeastern Alaska.

"We know something of the mechanics and dynamics of sedimentation, but regarding some phases we still have much to learn. We know, for example, that some sediment is carried into streams in almost every instance where roads are built in the watersheds. Through watershed studies, we are attaining a better understanding of the way in which sediment reaches the mainstream as a result of road construction and logging activities (chiefly by way of the lateral tributaries)."

(49) Sheridan, William L., and William J. McNeil
1968. Some effects of logging on two salmon streams in Alaska. J. For. 66(2):128-133.

"Sedimentation of spawning beds and density of pink salmon (*O. gorbuscha*) were observed before and after logging in two streams in southeastern Alaska. The study lasted seven years (1958-1964). Although the amount of fine particles in spawning beds increased temporarily, the amount in 1964 (five years after logging began) was not significantly greater than

in 1959. Densities of salmon spawners and fry increased in the sampling areas during the period of this study. The increases were probably due to the abolition in 1959 of salmon traps (formerly the primary means of catching salmon)."

(50) Stephens, F. R.
1966. Soil and watershed characteristics of southeast Alaska and some western Oregon drainages. USDA For. Serv. Alaska Reg., 16 p. Juneau, Alaska.

Stephens states that the results of any study on the effects of land management on streams cannot be universally applied to all streams unless the land characteristics of each area are known and are comparable. To illustrate the variability of land characteristics which influence the hazards of sedimentation, four areas are compared: the South Umpqua, Alsea, and Bull Run drainages in Oregon, and southeast Alaska.

(51) Swanston, D. N.
1971. Principal mass movement processes influenced by logging, road building, and fire. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 29-40. Oreg. State Univ., Corvallis.

"Dominant natural soil mass movement processes active on watersheds of the western United States include 1) debris avalanches, debris flows and debris torrents; 2) slumps and earth flows; 3) deep-seated soil creep; and 4) dry creep and sliding. A dominant characteristic of each is steep slope occurrence, frequently in excess of the angle of stability of the soil. All but dry creep and sliding occur under high soil moisture conditions and usually develop or are accelerated during periods of abnormally high rainfall. Further, all are encouraged or accelerated by destruction of natural mechanical support on the slopes. Logging, road building, and fire play an important part in initiation and acceleration of these soil mass movements. Road building stands out at the present time as the most damaging activity, with soil failures resulting largely from slope loading, back-slope cutting, and inadequate slope drainage. Logging and fire affect stability primarily through destruction of natural mechanical support for the soils, removal of surface cover, and obstruction of main drainage channels by debris."

(52) Swanston, Douglas N.
1967. Debris avalanching in thin soils derived from bedrock. USDA For. Serv. Res. Note PNW-64, 7 p., illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"On slopes steeper than the internal angle of friction and in the absence of a well-developed, cohesive soil, landslides must be considered a natural erosion process responding to the basic laws of physics.

They are an inevitable result of any occurrence which tends to reduce the resistance of a slope to sliding.

"Many of these slopes remain stable for years despite the action of external forces tending to reduce their resistance to sliding. The slope soils, therefore, must possess a slide resistance which is not directly related to the physical properties of the soil. Present indications are that this force is produced by tree rooting through the soil and into cracks in the underlying bedrock. Destruction of this rooting system would greatly increase susceptibility of the slope soil to slides."

(53) Swanston, Douglas N.
1969. Mass wasting in coastal Alaska. USDA For. Serv. Res. Pap. PNW-83, 15 p., illus. Pac. Northwest For. & Range Exp. Stn., Inst. North. For., Juneau, Alaska.

"This paper summarizes and interprets the accumulated data and knowledge about slope erosion in southeast Alaska, particularly in relation to recently logged areas, with general suggestions and guidelines for prediction and control."

(54) Swanston, Douglas N.
1970. Mechanics of debris avalanching in shallow till soils of southeast Alaska. USDA For. Serv. Res. Pap. PNW-103, 17 p., illus. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"Studies in the Maybeso valley show that the majority of debris avalanches and flows develop on slopes greater than 34° and are especially frequent around a critical angle of 37°. On an isosinal contour map of Maybeso valley...this angle is represented by the critical contour 0.6, the sine of 37°. Above this critical contour, sliding is imminent with the destruction or disruption of any cohesive forces acting to hold the soil in place. Below the critical contour is a zone of decreasing instability. The zone of instability thus defined is located principally in the deeper stream notches and in a narrow band near the 1,200-foot contour. The narrow band in the vicinity of maximum slide activity corresponds to the steep face of a till shoulder marking the upper limit of younger till.

"By construction of an isosine map, or more simply mapping of slope angles, areas of general slope instability within a watershed can be located and the feasibility of applying preventive or control measures determined. If the area of instability is a bedrock cliff, no additional consideration need be given. If the area lies within some of the best timber stands, serious thought should be given to harvesting techniques and road construction in the critical area."

(55) Tebo, L. B., Jr.
1955. Effects of siltation, resulting from improper logging on the bottom fauna of a small trout stream in the southern Appalachians. Progr. Fish-Cult. 17(2):64-70.

Logging influenced the bottom fauna of a small trout stream in the Coweeta Experimental Forest. Bottom fauna were selected to measure the effects of siltation on a stream community. Logging practices were those used commonly in the southeastern States. Results indicated that poorly planned road systems and skid trails result in a high rate of erosion and siltation in stream channels. Properly constructed roads will benefit the logger by reducing road maintenance.

(56) Tebo, L. B., Jr.
1957. Effects of siltation on trout streams. Soc. Am. For. Proc. 1956:198-202.

A study of the Coweeta Experimental Forest in western North Carolina showed that soil erosion and siltation reduced and, in severe cases, even destroyed the trout fishery by (1) inhibiting spawning success, (2) reducing the available food supply, and (3) changing the physical characteristics of the habitat so as to make it unsuitable for trout.

(57) Ursic, S. J.
1965. Sediment yields from small watersheds under various land uses and forest covers. U.S. Dep. Agric. Misc. Publ. 970: 47-52.

"Data from small watersheds in the hilly uplands of northern Mississippi show large variations in annual runoff and sediment production attributable to land use and cover types. Runoff decreased in the order: corn and pasture > abandoned fields and depleted hardwoods > pine plantations. Annual sediment yields and average concentrations of sediment per unit of runoff decreased in the order: corn > pasture > abandoned fields and depleted hardwoods > pine plantations and mature pine-hardwoods. These progressions represent discrete populations of erosion potential.

"Runoff was greater from watersheds with loessial soils than from those with both loess and Coastal Plain soils, but the effect of soil on sediment yields was not consistent for all covers.

"Extremes in annual sediment production ranged from 43 tons per acre from a cultivated watershed to a few pounds per acre from pine plantations. Sediment yields from abandoned fields with a dense cover of native grass and from forest covers did not exceed 0.5 ton per acre annually. By contrast, yields from gullies in the same locality have been reported as 84 to 400 tons per acre.

"The studies are yielding data that should eventually allow prediction of sediment production and permanent covers. They suggest opportunities for reducing runoff and sediment by changing land use and cover types.

"Establishing pine on actively eroding abandoned fields has in two decades reduced sedimentation to amounts probably not in excess of the geologic norm for undisturbed climax forests in this area."

(58) Wallis, James R.
1963. Logging for water quality in northern California. USDA For. Serv. Res. Note PSW-N23, 7 p. Pac. Southwest For. & Range Exp. Stn., Berkeley, Calif.

"Eleven 'do's' and 'don'ts' of logging for preserving water quality are listed and tips for recognizing the more erodible sites are given."

(59) Wickett, W. P.
1959. Effects of siltation on success of fish spawning. *In* E. F. Eldridge and John N. Wilson [eds.], Proceedings 5th symposium--Pacific Northwest on siltation--its source and effects on aquatic environment, p. 16-17. U.S. Dep. Health, Educ. & Welfare, Portland, Oreg.

Effects of siltation on salmon are discussed.

(60) Wilson, John N.
1960. Effects of turbidity and silt on aquatic life. *In* Clarence M. Tarzwell [ed.], Transactions 1959 seminar on biological problems in water pollution. U.S. Public Health Serv. Tech. Rep. W60-3:235-239. Robert A. Taft Sanit. Eng. Cent., Columbus, Ohio.

Effects of turbidity and silt on aquatic life and a consideration of the establishment of water quality criteria for silt and turbidity in natural waters are discussed.

(61) Wustenberg, Donald W.
1954. A preliminary survey of the influences of controlled logging on a trout stream in the H. J. Andrews Experimental Forest, Oregon. 51 p. M.S. thesis, Oreg. State Coll., Corvallis.

The staggered-setting system of logging in mature Douglas-fir stands affects trout environments. Findings included: (1) an increase in localized sediment entering the stream associated with maintenance and use of logging roads, (2) a lack of pronounced increases in sediment concentrations as a result of logging, (3) a fine silt consistency for most sediments, (4) a preponderance of sediment concentrations in the upper parts of small tributaries, (5) a greater disruption of streambeds from

tractor logging than from high-lead logging, (6) severe scouring in logged streams during high flows in comparison with relatively undisturbed conditions in unlogged sections of the same streams, (7) the elimination of cutthroat trout populations in logged streams and adverse effects on aquatic insects for at least one year, and (8) the possibility of reduction in water temperatures through the use of streamside buffer strips.

STREAMSIDE VEGETATION

(62) Brazier, Jon R., and George W. Brown
1972. Buffer strips for stream temperature control. Oreg. State Univ. Res. Pap. No. 15, 12 p.

"The purposes of this research bulletin are to show which buffer strip characteristics are important in regulating the temperature of small streams and to describe a method of designing buffer strips that will insure no temperature change and at the same time minimize the amount of commercial timber left in the strip to provide the necessary shade."

(63) Burns, J. E.
1970. The importance of streamside vegetation to trout and salmon in British Columbia. Dep. Recreation & Conserv., Vancouver Island Reg., Fish & Wildl. Branch, Fish. Tech. Circ. 1, 10 p. Nanaimo, B.C., Can.

"Salmonids are adapted to cool, well oxygenated streams that have traditionally been relatively free of sediment and have been provided with energy sources and cover from streamside vegetation. Environmental disturbances such as the removal of the streamside canopy, erosion, sedimentation, debris deposition and spraying of toxins have resulted in the loss of much productive stream habitat for trout and salmon in Northwestern North America. The magnitude of this loss could have been reduced significantly by treating the stream as an integral part of the total forest environment and leaving streamside vegetation, a small part of the environment, relatively undisturbed."

(64) Cormack, R. G. H.
1949. A study of trout streamside cover in logged-over and undisturbed virgin spruce woods. Can. J. Res. 27(3):78-95. [Taken from Cordone (148).]

"The purpose of the survey was to obtain information concerning the vegetation of undisturbed and disturbed forest areas, to analyze the information and to relate it to the problems of soil erosion, water conservation, and trout stream management.

"From evidence obtained in the present survey one measure of stream protection that seems most desirable would be the prohibition of all cutting along wide strips on both sides of the stream. There is considerable precedent for advising a policy of this kind, as multiple use forestry admits non-cutting in certain areas, if it is genuinely needed. The width of the strips to be left uncut will undoubtedly vary with the individual stream and with the type of forest cover. Taking conditions in the Carbondale River Valley as more or less general for this part of the watershed the writer suggests as a beginning point a strip of at least 60 feet on each side of the stream. Certainly the uncut areas should be wide enough to provide the maximum of shade and protection to both stream

and streamside cover and to preserve the natural attractiveness of the stream. Also they should be extensive enough to include the stream's source, springs, and small feeder tributaries."

(65) DeWitt, John W.
1968. Streamside vegetation and small coastal salmon streams. *In* Richard T. Myren [ed.], Forum on the relation between logging and salmon, p. 38-47. Proc. Forum Am. Inst. Fish. Res. Biol., Alaska Dist., Juneau, Alaska.

"The main purpose of this talk is to review some general considerations of the influence of streamside vegetation, especially its stream canopy aspects as affected by canopy removal, on the conditions and ecology of small coastal salmon streams. Some of the direct effects that I shall ascribe to changes in streamside vegetation can also be the result of changes in vegetation on slopes and ridges well away from the stream. The streams I am referring to are those of minimum flow of only a few cubic feet per second. In areas of virgin and recovered forest, these streams tend to have well-vegetated banks and to be well shaded."

(66) Green, Geoffrey E.
1950. Land use and trout streams. J. Soil & Water Conserv. 5(3):125-126.

A study in the Coweeta Experimental Forest of North Carolina compared stream temperatures of two streams--an agricultural stream and an undisturbed forest stream. As was expected, shading was the key to control of stream temperatures. The agricultural stream with little shade ranged from 9°-20° F higher than the forest stream.

(67) Johnson, Fred W.
1953. Forests and trout. J. For. 51(8):551-554.

The author states that:

"...Stream-bank vegetation helps to maintain such [deep-water] areas through the reduction of lateral erosion. Strips of timber left along stream banks...provide this needed protection against lateral erosion. Moreover, they also serve as buffers that arrest silt flows from skid trails and logging roads. During summer rainstorms, the writer has observed that silt flows fan out within 20 or 30 feet after entering the undisturbed mat of pine needles and other forest litter."

The article discusses trout-forest relationships in general but probably refers to the Rocky Mountain area.

(68) McMynn, R. G.
1970. "Green belts" or "leave strips" to protect fish! Why? Dep. Recreation & Conserv., Commer. Fish. Branch, 36 p. Victoria, B.C., Can.

Papers concerning logging practices in relation to water management and fish production are reviewed; first, to outline how logging practices can affect a watershed, and second, to explain how "leave strips" or "green belts" can be important in offsetting some of the detrimental effects of logging.

(69) McMynn, Robert
1970. Strips of trees could protect fish from loggers. West. Fish. 80(6):20-24.

Benefits of "leave strips" or "green belts" along streams are discussed. Author states that such strips or belts would provide the most valuable means of protecting streams from harmful effects of logging on fish.

(70) Sadler, Ronald R.
1970. Buffer strips--a possible application of decision theory. Bur. Land Manage. Tech. Note, 11 p. U.S. Dep. Inter. Portland, Oreg.

The economic values of leaving buffer strips for stream protection are discussed. The article includes various formulas to determine economic value of the fishery as compared with the value of the timber in the buffer strips.

(71) Streeby, Larry
1971. Buffer strips--some considerations in the decision to leave. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 194-198. Oreg. State Univ., Corvallis.

"Buffer strips have been receiving a great deal of attention as a method of protecting streams and the stream environment. But they are not equally useful in all places. The desirability of applying buffer strips is dependent on three classes of factors--physical-biotic factors, outside cultural factors, and management objectives. Some potential costs and benefits associated with buffer strips are identified, but all these costs and benefits should not be expressed in dollar terms. Rather, all costs and benefits associated with each management objective should be explicitly recognized in their own natural measure of contribution to goals, and decisions should be made on the basis of this information."

WATER QUALITY

(72) Allen, E. J.
1960. Water supply watershed problems - Seattle watershed. *In* E. F. Eldridge [ed.], Proceedings 7th symposium water pollution research, p. 15-17. U.S. Public Health Serv., Reg. IX, Portland, Oreg.

Watershed activities which have a deleterious effect upon the quality or quantity of water are discussed. The author suggests that the solution is multiple use management.

(73) Atkinson, Sheridan William
1971. BOD and toxicity of log leachates. 96 p. M.S. thesis, Oreg. State Univ., Corvallis.

"A series of log storage experiments was conducted to determine whether leachates derived from water storage of logs are acutely toxic to fish. Log segments approximately 18 inches long and 16 inches in diameter were stored in tanks and held submerged for a period of 7 days. The holding water containing leached materials was made toxic with mercury to retard biological decomposition of the leached substances. Mercury was selectively removed from leachate samples by chelation prior to biochemical oxygen demand (BOD) and bioassay testing.

"Trout and salmon fry were subjected to the leachate water in short term acute bioassay tests. Results are reported as a median tolerance limit, (TLm), i.e., the concentration of leachate at which 50 percent of the test fish died for any given exposure time. Leachates were also tested for BOD_5, BOD k-rate, chemical oxygen demand (COD), wood sugar and Pearl Benson Index (PBI).

"Test results show that leachates from Douglas fir stored in fresh water exert a slight acute toxicity to fish. A TLm_{96} of 20 percent leachate by volume, for a 50 year old Douglas fir log, was the most toxic leachate observed. Leachates from ponderosa pine, hemlock and older fir log stored under identical conditions produced no measurable acute toxicity. Leachates contained a significant quantity of BOD and PBI exerting substances. The highest BOD_5, (1.36 g/ft^2 of submerged surface area) was exerted by leachate from a ponderosa pine log segment stored with bark removed. The highest PBI value (12.5 g/ft^2), was observed for leachate from a young Douglas fir log segment. BOD:COD ratios and BOD k-rate ranged widely for the various leachates, but were relatively low which indicated a significant fraction of non-biodegradable substances. Hoffbuhr...also observed a high non-biodegradable fraction in samples taken from log storage ponds. Wood sugars were found to account for a large part of the degradable portion of leachates. Leachates from ponderosa pine log with bark intact exerted a high BOD and also contained the highest concentration of wood sugar observed, 0.84 g/ft^2."

(74) Bormann, F. H., G. E. Likens, D. W. Fisher, and R. S. Pierce
1968. Nutrient loss accelerated by clear cutting of a forest ecosystem. Science 159:882-884.

"The forest of a small watershed-ecosystem was cut in order to determine the effects of removal of vegetation on nutrient cycles. Relative to undisturbed ecosystems, the cut ecosystem exhibited accelerated loss of nutrients: nitrogen lost during the first year after cutting was equivalent to the amount annually turned over in an undisturbed system, and losses of cations were 3 to 20 times greater than from comparable undisturbed systems. Possible causes of the pattern of nutrient loss from the cut ecosystem are discussed."

(75) Bridges, W. R.
1965. Some effects on fish of chemical control of forest insects. Soc. Am. For. Proc. 1964:192-194.

"This paper deals primarily with some of the effects on fish caused by DDT aerial sprays conducted for forest insect control. Some aspects associated with the use of other less toxic chemicals are also considered."

(76) Brown, George W.
1969. Predicting temperatures of small streams. Water Resour. Res. 5(1):68-75.

"Hourly temperatures of small streams can be accurately predicted using an energy balance. Micrometeorological measurements are required to assess the environment of the small stream accurately. The temperature-prediction technique was tested on three streams in Oregon. On unshaded stretches, net all-wave radiation is the predominant energy source during the day; evaporation and convection account for less than 10% of the total energy exchange. Conduction of heat into the stream bottom is an important energy balance component on shallow streams having a bedrock bottom. Up to 25% of the energy absorbed by such a stream may be transferred into the bed. Hourly temperature changes of 0-16° F were predicted to within 1° F more than 90% of the time. This technique permits foresters to control water temperature through manipulation of stream-side vegetation."

(77) Brown, George W.
1970. Predicting the effect of clearcutting on stream temperature. J. Soil & Water Conserv. 25(1):11-13.

"The temperature change that occurs between two points on a stream is directly proportional to the surface area of the stream and the heat load applied between these points. It is inversely proportional to the flow. Good estimates of the heat load can be made with solar radiation data if the stream is uniformly exposed to sunlight. Foresters can use this technique to predict the effect of clearcutting on stream temperature."

(78) Brown, George W.
1971. Water temperature in small streams as influenced by environmental factors and logging. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 175-181. Oreg. State Univ., Corvallis.

"Clearcut logging can produce large changes in the temperature of small streams. The principal source of heat affected by clearcutting is direct solar radiation. Shade removal may increase radiation loads by six to seven times. Temperature control can best be achieved by providing shade between the boundary of the clearcut and the stream. Adequate shade may be provided by brush species if streams are very small. The impact, both at the site and downstream, of exposing given amounts of stream surface to direct solar radiation is predictable."

(79) Brown, George W.
1972. An improved temperature prediction model for small streams. Water Resour. Res. Inst., Rep. WRRI-16, 20 p. Oreg. State Univ., Corvallis.

"A model for predicting the maximum change in temperature from completely exposing a reach of stream to solar radiation was developed during earlier research. This model, which assumes that net solar radiation is the sole source of energy to the stream, worked well on most streams. In a few cases it worked very poorly. These streams contained either a large proportion of pools or bed rock in the stream bottom. We found that only the flowing portion of the pools should be included in the heat exchange process. We also found that the bed rock stream bottoms can conduct about 20% of the incident solar radiation away from the stream. Reducing our estimates of stream surface area and net heat load according to pool configuration and bed condition provided good estimates of temperature change using the original model."

(80) Brown, George W., and James T. Krygier
1967. Changing water temperatures in small mountain streams. J. Soil & Water Conserv. 22(6):242-244.

The results from two studies show that clearcutting influences summer temperatures in small Oregon coastal streams. The integrated effect of numerous clearcuttings on small tributary streams may be a significant source of thermal pollution.

(81) Brown, George W., and James T. Krygier
1970. Effects of clear-cutting on stream temperature. Water Resour. Res. 6(4):1133-1139.

"The principal source of energy for warming streams is the sun. The amount of sunlight reaching the stream may be increased after clear-cut logging. Average monthly maximum temperatures increased by

14° F and annual maximum temperatures increased from 57° to 85° F one year after clear-cut logging on a small watershed in Oregon's coast range. In a nearby watershed where strips of brush and trees separated logging units from the stream, no changes in temperature were observed that could be attributed to clear-cutting."

(82) Brown, George W., Gerald W. Swank, and Jack Rothacher
1971. Water temperature in the Steamboat drainage. USDA For. Serv. Res. Pap. PNW-119, 17 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"Stream temperatures were studied in a drainage in which logging operations were typical of much of the commercial forests on the west slopes of the Cascade Range. Changes in water temperature of tributary streams influenced by various degrees of exposure from logging were measured, and a simplified prediction equation was tested."

(83) Bullard, William
1963. Water quality problems originating on wild lands. *In* Symposium on forest watershed management, p. 313-319. Oreg. State Univ., Corvallis.

The water quality problems originating on wild lands and some possible solutions to these problems are discussed.

(84) Eschner, Arthur R., and Jack Larmoyeux
1963. Logging and trout: four experimental forest practices and their effect on water quality. Progr. Fish-Cult. 25(2):59-67.

Results of studies conducted in West Virginia are discussed:

"Experimental logging of watersheds caused significant changes in quantity and quality of streamflow.

"Poorly located and constructed skidroads resulted in continuous, very high stream turbidities during logging. This effect diminished with time after logging disturbance ended. Carefully planned and constructed skidroads contributed negligible amounts of turbidity.

"Clearcutting resulted in significantly higher maximum stream temperatures in the growing season, lower minimum temperatures in the dormant season. Maximum stream temperatures above those generally tolerated by brook trout were noted often in the summer of 1959. Moderate cutting did not produce water-quality changes that might be harmful to trout.

"Increases in pH, alkalinity, and specific conductance were noted in the stream flowing from the clearcut watershed.

"Streamflow was increased by the treatments in proportion to the amount of timber cut and killed. Most of the increases came late in summer and early in fall, the periods of high evapotranspiration and soil moisture recharge, when flow in many trout streams is dangerously low.

"Changes in stream pH, alkalinity, and temperature are persisting; but treatment effects on quantity of flow and turbidity are diminishing as time passes."

(85) Fredriksen, R. L.
1971. Comparative chemical water quality - natural and disturbed streams following logging and slash burning. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 125-137. Oreg. State Univ., Corvallis.

"The loss of nutrients from an old-growth Douglas-fir forest was measured in the streams of experimental watersheds. Following timber harvest and slash burning, loss of nutrients cations increased 1.6 to 3.0 times the loss from the undisturbed watershed. A surge of nutrients that followed broadcast burning contained concentrations of ammonia and manganese that exceeded Federal water quality standards for a period of 12 days. Annual nitrogen loss following burning averaged 4.6 pounds per acre; 53 percent of this was organic nitrogen contained in sediment. Inorganic nitrogen, dissolved in the stream, made up the remaining part. Annual loss of nitrogen from the undisturbed forest was very small--.16 pound per acre."

(86) Gibson, H. R., and D. W. Chapman
1972. Effects of Zectran insecticide on aquatic organisms in Bear Valley Creek, Idaho. Trans. Am. Fish. Soc. 101(2):330-344.

"We assessed effects of the experimental insecticide Zectran® on aquatic organisms in Bear Valley Creek, Idaho in 1966. Hayden Creek drainage, nearby and not sprayed, served as a control. We found no significant fish mortality, and no effect on growth rate and condition of age 0+, 1+, 2+, and 3+ dolly varden (*Salvelinus malma*). Insecticide applications did not increase emigration and intrastream movement of fish. We noted no effects on benthic aquatic insect numbers, but observed that more insects drifted downstream for several hours beginning about 3 hours after spraying on July 7, 1966. Adult terrestrial insects, immature Heptageneidae and Rhyacophilidae, adult Chloroperlidae, and immature and adult Phryganeidae, Limnephilidae, and Blephariceridae increased in drift samples after spraying. We concluded that the Zectran insecticide damaged aquatic organisms very little."

(87) Goldman, Charles R.
1967. Effects of pesticides in California watersheds. *In* Man's effect on California watersheds, p. 211-217. Part III, 1965-1967. Sacramento, California.

The effects of pesticides on both the aquatic and terrestrial habitats are discussed. A list of needed research and legislation in California is also included.

(88) Gordon, Robert, and Dennis Martens
1969. Sockeye eggs killed by bark on spawning gravel. West Fish., Sept., p. 41-43.

"Dangers of log-driving on salmon spawning streams are being studied by the Salmon Commission. Two biologists outline their findings, which conclude that concentrations of bark over four percent of the gravel surface are detrimental. Resumption of the Stellako log drive, they say, would be 'ill-advised.'"

(89) Graham, John LeRoy
1970. Pollutants leached from selected species of wood in log storage waters. 46 p. M.S. thesis, Oreg. State Univ., Corvallis.

"A study was conducted to determine the quantity and character of substances leached from logs floating in water, and the rate of leaching of these substances. The species of wood studied were Douglas fir and ponderosa pine. The research was carried out in a controlled laboratory environment with log sections 14-inches in diameter by 20-inches long. The study included log sections submerged in both tap water and saline water. The holding water was chemically poisoned to prevent biological degradation of the leached materials.

"The analyses performed on samples of the holding water taken at specified intervals during 40 day leaching periods included chemical oxygen demand (COD), Pearl-Benson Index (PBI), total solids (TS), total volatile solids (TVS) and total organic carbon (TOC).

"The data showed that ponderosa pine logs contributed measurably greater quantities of soluble organic materials and color-producing substances than Douglas fir logs. The following COD and PBI values were measured after a leaching period of 20 days: ponderosa pine - 4.3 g COD/ft^2, 15 g PBI/ft^2; Douglas fir - 3.2 g COD/ft^2, 11 g PBI/ft^2.

"Leaching rate appeared to be affected by the concentration of soluble organic materials in the stagnant holding water; however, experiments showed that, in flowing water, the leaching rate was nearly constant.

"Extrapolation of the laboratory test data to field conditions resulted in an estimate of nearly 800 pounds of COD per day contributed by approximately 8 million board feet of floating logs to a typical log storage water."

(90) Gray, J. R. A., and J. M. Edington
1969. Effect of woodland clearance on stream temperature. J. Fish. Res. Board Can. 26:399-403.

"A study was made of the temperature characteristics of a stream which flowed first through open fields and then through woodland. When the woodland was felled, that section of the stream showed a marked rise in summer temperature. It is argued that the presence or absence of tree shading can be the decisive factor in determining the temperature of small streams."

(91) Griffin, L. E.
1938. Experiments on tolerance of young trout and salmon for suspended sediment in water. Oreg. State Dep. Geol. Miner. Ind. Bull. No. 10, Append. B., p. 28-31. Portland, Oreg.

The preliminary examination of data from a study on the tolerance of young trout and salmon to suspended sediment indicated that young trout and salmon are not directly injured by heavily silted water.

(92) Grondal, Bror L.
1945. Relation of runoff and water quality to land and forest use in Cedar River watershed. J. Am. Water Works Assoc. 37(1): 15-20.

A study commission formed with the primary objective of deciding the future policies in the Cedar River watershed with respect to logging recommended a continuation of logging in the watershed on a controlled sustained-yield basis.

(93) Klock, G. O.
1971. Streamflow nitrogen loss following forest erosion control fertilization. USDA For. Serv. Res. Note PNW-169, 9 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"Three gaged watersheds, approximately 500 hectares in size, in north central Washington were severely burned in 1970 by wildfire. In an experimental erosion control seeding program, two watersheds were fertilized, one with urea and the other with ammonium sulfate. The third watershed was retained as an unrehabilitated control. For a 60-day period during and following fertilization, 1.37 kilograms of urea-N and 2.90 kilograms of nitrate-N were estimated to have been carried by streamflow from the watershed fertilized with 27.5 metric tons of elemental nitrogen as urea. On the watershed fertilized with 33.16 metric tons of elemental nitrogen as ammonium sulfate, 1.45 kilograms of nitrate-N was estimated to have been transported from the watershed by streamflow."

(94) Kopperdahl, Fredric R., James W. Burns, and Gary E. Smith
1971. Water quality of some logged and unlogged California streams. Calif. Fish & Game, Inland Admin. Rep. 71-12, 19 p.

"Water quality was monitored in 1968 and 1969 in six coastal streams in northern California, four of which were subjected to logging and/or road building (Bummer Lake Creek, South Fork Yager Creek, Little North Fork Noyo River, and South Fork Caspar Creek), while the others remained undisturbed (Godwood Creek and North Fork Caspar Creek). The purposes of this study were to characterize the water quality of the streams, to determine if the logging and road construction drastically altered water quality, and to collect water quality data which could be tested for predicting stream carrying capacities for salmonids.

"Conditions were generally suitable for salmonids during and after the logging. No abnormal concentrations of dissolved oxygen, alkalinity, hardness, dissolved solids, phosphate, chloride, sulfate, nitrate, tannin and lignin, or pH were detected. Carbon dioxide was low in most streams, except in South Fork Caspar Creek when it reached 8 ppm during decomposition of logging debris in the summer of 1968. Turbidity was highest in areas where bulldozers were working in the streams. Temperatures of most streams increased after the logging, but seldom exceeded 70° F because of the cool climate in the coastal fog belt. Alternating cut and uncut blocks on one stream, and retaining a buffer strip along another, kept temperatures low in two streams."

(95) Kramer, Robert H., and Lloyd L. Smith, Jr.
1965. Effects of suspended wood fiber on brown and rainbow trout eggs and alevins. Trans. Am. Fish. Soc. 94:252-258.

"Brown and rainbow trout (*Salmo trutta* and *S. gairdneri*) eggs were held in continuous-flow suspensions of 0-, 60-, 125-, and 250-ppm conifer groundwood fiber 6 to 8 days before hatching. Resulting alevins were held in the same fiber concentrations until swimup (14 to 16 days), then removed and maintained in clean water for up to 91 days. Suspended fiber had no effect upon egg survival, respiration rate of embryos, or growth rates of alevins and juveniles from eggs incubated in fiber but hatched and grown in clean water. When alevins were held in wood-fiber suspensions, survival was reduced from 98 to 100 per cent in controls to 0 to 72 per cent in 250-ppm fiber; respiration rate from 336.6 mm^3/g per hour in controls to 146.3 in 125-ppm fiber; breathing rate from 1.39 to 1.92 respiratory movements per second in controls to 0.52 to 0.97 in 250-ppm fiber; heart rate from 1.50 to 1.60 beats per second in controls to 0.67 to 1.33 in 250-ppm fiber; and instantaneous growth rate (g) from .0213 to .0345 in controls to .0061 to .0062 in 250-ppm fiber. Growth rate of rainbow trout juveniles in clean water after exposure to fiber during the alevin stage was significantly reduced only in the 250-ppm-fiber group. Concurrent tests indicated that observed effects were due to the fiber and not to residues of a mercuric slimicide added to the fiber at the paper mill."

(96) Lantz, Richard L.
1971. Influence of water temperature on fish survival, growth and behavior. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 182-193. Oreg. State Univ., Corvallis.

"Water temperature can control the functions and activities of freshwater fishes since their body temperature is similar to the temperature of their environment. The removal of streamside vegetation during logging operations can increase water temperatures. Such temperature increases would be most significant on small streams, which are essential to the production of salmon and trout in the Pacific Northwest. A general technical review of the effects of temperature on fish survival, growth, and behavior is presented. Concepts regarding the thermal requirements of fishes are summarized. Buffer strips of vegetation along streams are suggested as an important land management tool. In addition to eliminating or minimizing water temperature increases, buffer strips serve other purposes and provide for true multiple-use of the resources of our watersheds."

(97) Levno, Al, and Jack Rothacher
1967. Increases in maximum stream temperatures after logging in old-growth Douglas-fir watersheds. USDA For. Serv. Res. Note PNW-65, 12 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"...In this study, mean monthly temperature increases of 7° to 12° F. persisted from April through August, following direct exposure of the stream channel by scouring during the 1964 flood...

"Under the pattern of patch clearcuts commonly used in the Douglas-fir region, little or no increase in maximum stream temperatures would be expected unless a large proportion of the streambed was directly exposed to solar radiation. Protection of any streamside vegetation which provides some shade to the stream will apparently help prevent excessive increases in maximum water temperatures."

(98) Levno, Al, and Jack Rothacher
1969. Increases in maximum stream temperatures after slash burning in a small experimental watershed. USDA For. Serv. Res. Note PNW-110, 7 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"The first year after slash was burned on a 237-acre clearcut watershed in the Cascade Range of Oregon, average maximum water temperatures increased 13°, 14°, and 12° F. during June, July, and August. A maximum stream temperature of 75° F. persisted for 3 hours on a day in July."

(99) Likens, Gene E., F. Herbert Bormann, Noye M. Johnson, and others 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed-ecosystem. Ecol. Monogr. 40(1):23-47.

"All vegetation on Watershed 2 of the Hubbard Brook Experimental Forest was cut during November and December of 1968, and vegetation regrowth was inhibited for two years by periodic application of herbicides. Annual stream-flow was increased 33 cm or 39% the first year and 27 cm or 28% the second year above the values expected if the watershed were not deforested.

"Large increases in streamwater concentrations were observed for all major ions, except NH_4+, SO_4= and HCO_3-, approximately five months after the deforestation. Nitrate concentrations were 41-fold higher than the undisturbed condition the first year and 56-fold higher the second.... Sulfate was the only major ion in stream water that decreased in concentration after deforestation.... Average streamwater concentrations increased by 417% for Ca++, 408% for Mg++, 1558% for K+ and 177% for Na+ during the two years subsequent to deforestation. Budgetary net losses from Watershed 2 in kg/ha-yr were about 142 for NO_3-N, 90 for Ca++, 36 for K+, 32 for SiO_2-Si, 24 for Al+++, 18 for Mg+++, 17 for Na+, 4 for Cl-, and 0 for SO_4-S during 1967-68; whereas for an adjacent, undisturbed watershed (W6) net losses were 9.2 for Ca++, 1.6 for K+, 17 for SiO_2-Si, 3.1 for Al+++, 2.6 for Mg++, 7.0 for Na+, 0.1 for Cl-, and 3.3 for SO_4-S. Input of nitrate-nitrogen in precipitation normally exceeds the output in drainage water in the undisturbed ecosystems, and ammonium-nitrogen likewise accumulates in both the undisturbed and deforested ecosystems. Total gross export of dissolved solids, exclusive of organic matter, was about 75 metric tons/km^2 in 1966-67, and 97 metric tons/km^2 in 1967-68, or about 6 to 8 times greater than would be expected for an undisturbed watershed.

"The greatly increased export of dissolved nutrients from the deforested ecosystem was due to an alteration of the nitrogen cycle within the ecosystem.

"The drainage streams tributary to Hubbard Brook are normally acid, and as a result of deforestation the hydrogen ion content increased by 5-fold (from pH 5.1 to 4.3).

"Streamwater temperatures after deforestation were higher than the undisturbed condition during both summer and winter. Also in contrast to the relatively constant temperature in the undisturbed streams, streamwater temperature after deforestation fluctuated 3-4°C during the day in summer.

"Electrical conductivity increased about 6-fold in the stream water after deforestation and was much more variable.

"Increased streamwater turbidity as a result of the deforestation was negligible, however the particulate matter output was increased about 4-fold. Whereas the particulate matter is normally 50% inorganic materials, after deforestation preliminary estimates indicate that the proportion of inorganic materials increased to 76% of the total particulates."

(100) McCall, Merley
1970. The effects of aerial forest fertilization on water quality for two streams in the Capitol forest. Wash. State Dep. Ecol., 14 p. Olympia.

"The studies of two streams in the fall and winter of 1969/1970 indicated that aerial application of a urea fertilizer to the forested areas in the watersheds resulted in a rapid increase in urea concentration in the water. This was likely due to the direct application to feeder streams. Further sampling shows the urea concentration to fall to background levels within one month. After a month the nitrogen lost is apparently in the form of nitrate only. The overall effect on the water quality was to significantly change the nitrogen levels, although the change was of short duration."

(101) McNeil, William J.
1962. Variations in the dissolved oxygen content of intragravel water in four spawning streams in southeastern Alaska. U.S. Fish & Wildl. Serv. Spec. Sci. Rep., Fish. 402, 15 p.

"Inexpensive equipment for sampling intragravel water for dissolved oxygen is described. Water samples were withdrawn from plastic standpipes driven into the streambed. Dissolved oxygen values representative of points sampled were obtained from 30-ml. samples of water taken about 24 hours after standpipes were placed.

"Fourfold seasonal and yearly changes in dissolved oxygen levels were observed. Spatial differences in dissolved oxygen levels were greatest when discharge was low and temperature was high.

"For routine measurement of dissolved oxygen level random sampling was tried and found to be satisfactory."

(102) Meehan, William R.
1968. Relationship of shade cover to stream temperature in southeast Alaska. *In* Richard T. Myren [ed.], Logging and salmon, p. 115-131. Proc. Forum Am. Inst. Fish. Res. Biol., Alaska Dist., Juneau, Alaska.

"Temperature measurements in several streams in upper southeastern Alaska indicate that shade-producing streamside cover is important in maintaining cool water. Stream temperatures increase rapidly in

unshaded reaches on clear, warm days and likewise cool quite quickly when the water passes through shaded reaches. On overcast days, the temperature increases as the water flows downstream, but to a much lesser extent than on clear days in open areas. Average temperature differences per 20 yards of stream channel exposed to solar radiation on warm, clear days were significantly different between streams in the Juneau-Haines area and in the Petersburg-Wrangell area. Such was not the case in shaded reaches and on overcast days."

(103) Meehan, William R.
1970. Some effects of shade cover on stream temperature in southeast Alaska. USDA For. Serv. Res. Note PNW-113, 9 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"Water temperatures were recorded in several southeast Alaska streams with a portable thermometer accurate to 0.01° C. Measurements were made at 20-yard intervals in shaded and unshaded reaches and on cloudy and clear days. Results indicate that (1) the effects of streamside cover on stream temperatures can be evaluated by this technique, and (2) shade-producing streamside cover is important in maintaining cool water."

(104) Norris, Logan A.
1968. Stream contamination by herbicides after fall rains on forest land. West. Soc. Weed Sci. Res. Prog. Rep., p. 33-34.

Based on previous studies and on a study of two Oregon streams, it was concluded that fall rains will not result in appreciable contamination of streams flowing through forest areas treated with phenoxy or amitrole herbicides. Unless heavy application is made directly into the stream, the major contribution of herbicides is overland movement of water and soil.

(105) Norris, Logan A., and Duane G. Moore
1971. The entry and fate of forest chemicals in streams. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 138-158. Oreg. State Univ., Corvallis.

"Initial distribution of aerially applied forest chemicals, mechanisms of their entry into, and their fate in the aquatic environment are considered. Research findings and long history of use have established that most forest chemicals offer minimum potential for pollution of the aquatic environment when they are used properly."

(106) Pacific Northwest Pollution Control Council
1971. Log storage and rafting in public waters. Task Force Rep. 56 p.

"Available research findings show that log debris, bark, and wood leachates resulting from log handling in public waters can adversely affect water quality. The range of effects varies from mild to gross depending upon the specific characteristics of both the involved water body and log handling practices. In most instances where logs depreciate water quality, there are a number of practicable changes that can be made to improve conditions.

"This report sets forth a number of recommendations for implementing improved log handling practices that will benefit water quality:

"1. Log storage and handling should be restricted in or eliminated from public waters where water quality standards cannot be met at all times or where these activities are a hindrance to other beneficial water uses such as small craft navigation.

"2. The free-fall, violent dumping of logs into water should be prohibited since this is the major cause and point source of loose bark and other log debris.

"3. Easy let-down devices should be employed for placing logs in the water, thereby reducing bark separation and the generation of other wood debris.

"4. Positive bark and wood debris controls, collection, and disposal methods should be employed at log dumps, raft building areas, and millside handling zones. This would be required for both floating and sinking particles.

"5. Log dumps should not be located in rapidly flowing waters or other water zones where positive bark and debris controls cannot be made effective.

"6. Accumulations of bark and other debris on the land and docks around dump sites should be kept out of the water.

"7. Whenever possible, logs should not be dumped, stored, or rafted where grounding will occur.

"8. Where water depths will permit the floating of bundled logs, they should be secured in bundles on land before being placed in the water. Bundles should not be broken again except on land or at millside.

"9. The inventory of logs in public waters for any purpose should be kept to the lowest possible number for the shortest possible time.

"10. Industry should provide and periodically update an accurate quantification of its use of public waters for log handling activities."

(107) Packer, Paul E.
1967. Forest treatment effects on water quality. *In* William E. Sopper and Howard W. Lull [eds.], Forest hydrology, p. 687-699. Oxford: Pergamon Press.

A review of information to determine the effects of forest treatments associated with timber harvesting has shown that: (1) undisturbed forests produce small amounts of sediment; (2) timber cutting does not adversely affect water quality except for increases in streamflow peaks, streamflow temperatures, and streambank erosion caused by increased discharge; (3) skidding of logs and logging can increase sedimentation considerably; and (4) roads that are inadequately drained or located too close to streams are the main cause of deterioration of water quality in forests.

(108) Packer, Paul E., and Harold F. Haupt
1966. The influence of roads on water quality characteristics. Soc. Am. For. Proc. 1965:112-115.

This paper discusses the impact of timber harvest roads and attempts to answer three questions: (1) How much sediment comes from forest roads and logging operations? (2) What are the harmful effects on stream biology? And, (3) What are some criteria for road location and drainage that will assure better water quality?

(109) Schaumburg, Frank D.
1970. Influence of log handling practices on water quality. *In* Water studies in Oregon, p. 1-9. Semin. Water Resour. Res. Inst., Oreg. State Univ., Corvallis.

The influence of log handling practices on water quality was evaluated in a study initiated in 1968. The results to date indicate that logging and log handling practices do contribute measurably to the pollution of natural waters. The effects of logging practices must be evaluated at each location to determine their real significance.

(110) Schaumburg, Frank D.
1970. The influence of log rafting on water quality. Annu. Rep. Res. Proj. WP-01320-01, 68 p. Oreg. State Univ., Corvallis.

Research activities on the influence of log rafting on water quality are summarized. The major portion of the report describes various projects including methods and apparatus used, experimental results,

and a discussion of the pertinent findings. Four technical publications are also included: (1) Pollutants leached from selected species of wood in log storage waters, (2) The quantity and distribution of bark debris resulting from water storage of logs, (3) Pollution associated with the water storage of logs - Part I: Bark debris; Part II: Leachates.

(111) Sears, Howard S., and William R. Meehan
1969. Short-term effects of 2,4-D on aquatic organisms in the Nakwasina River watershed, southeastern Alaska. Pestic. Monit. J. 5(2):213-217.

Preliminary results and analysis of data on the effects of aerial spraying of 2,4-D on aquatic organisms are presented. Results showed that 2,4-D caused no apparent significant immediate mortality on aquatic organisms.

(112) Servizi, J. A., D. W. Martens, and R. W. Gordon
1970. Effects of decaying bark on incubating salmon eggs. Int. Pac. Salmon Fish. Comm., Progr. Rep. 24, 28 p.

"The effect of bark contamination on salmon spawning grounds was assessed in laboratory tests on sockeye salmon (*Oncorhynchus nerka*) eggs and alevins. Bioassays showed that chemical toxicity of materials leached from bark of Douglas fir, Lodgepole pine, Englemann spruce and Alpine fir was not a factor influencing survival under the conditions tested. However, abundant growths of *Sphaerotilus* occurred on bark during initial stages of decay, causing severe mortalities among sockeye eggs and alevins owing to suffocation. In gravel-filled incubation boxes, contamination of gravel with bark caused significant reductions in survival from egg to fry at bark concentrations of 10% by volume, but 1% bark concentrations did not influence survival. Mortalities were attributed to blockage of intragravel water flow by bark particles. The oxygen demand of decaying bark was found to be relatively constant with time during the 683-day study. Calculations based on oxygen demand of bark indicated the amount of oxygen which would remain for egg incubation in natural redds at various temperatures and levels of bark contamination. Possible effects of various oxygen concentrations on size and emergence timing of fry were discussed and limiting amounts of bark recommended."

(113) Swift, Lloyd W., Jr., and James B. Messer
1971. Forest cuttings raise temperatures of small streams in the southern Appalachians. J. Soil & Water Conserv. 26(3): 111-116.

"Stream temperatures were measured during six forest-cutting treatments on small (23- to 70-acre) watershed in the southern Appalachian Mountains. Where forest trees and all understory vegetation were completely cut, maximum stream temperatures in summer increased from the normal 66° F to 73° or more. Some extreme treatments raised temperatures

more than 12° above normal. Where streambank vegetation was uncut or had regrown, summer maximums remained unchanged or declined from temperatures measured under uncut mature hardwood forest. Increases in stream temperature were judged to degrade water quality and constitute thermal pollution because, after each clearcut, water temperatures exceeded optimum levels for trout habitat."

(114) Tarrant, Robert F.
1967. Pesticides in forest waters--symptom of a growing problem. Soc. Am. For. Proc. 1966:159-163.

The water pollution problems associated with the application of forest chemicals are discussed.

(115) Thut, Rudolph N., and Eugene P. Haydu
1971. Effects of forest chemicals on aquatic life. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 159-171. Oreg. State Univ., Corvallis.

"Results of pesticide bioassays are not readily applicable to the conditions found after forest spray operations. They do have some value in determining the relative toxicities of the more widely used pesticides. The insecticides, particularly chlorinated hydrocarbons, are more toxic than most herbicides to aquatic life. There have been instances where insecticides applied to forests, particularly DDT, were directly toxic to stream life; such has not been demonstrated with herbicides applied to forests. Field studies conducted to date indicate that the concentrations of urea fertilizer and its breakdown are well below toxic thresholds for aquatic life. An increase in the rate of eutrophication of some lakes remains a possibility."

(116) Titcomb, John W.
1926. Forests in relation to fresh water fishes. Trans. Am. Fish. Soc. 56:122-129.

Titcomb states that where streamside vegetation is eliminated, water temperatures rise and that deforestation may cause silt to be carried into streams.

(117) USDA Forest Service
[n.d.] Guides for protecting water quality. Pac. Northwest Reg. 27 p. Portland, Oreg.

The purpose of this publication is "(1) to familiarize the user with some of the factors and influences that should be considered in making an on-the-ground decision on a case-by-case basis and (2) to provide a means for predicting temperature changes."

ALTERATION OF STREAMFLOW

(118) Anderson, Henry W., and C. H. Gleason
1960. Effects of logging and brush removal on snow water runoff. Hannoversch-Münden, Int. Assoc. Sci. Hydrol. 51:478-489.

The effects of snow accumulation, snowmelt, summer soil moisture losses, interception, and estimated water yields are documented. Snow melt was affected by logging slash disposal. The area in which the slash was piled and burned had 3-1/2 inches more runoff water in the late spring than did the area of untreated slash. Duration and quantity of water yield from snow zone runoff may be influenced by methods of logging and brush removal.

(119) Anderson, Henry W., and Robert L. Hobba
1959. Forests and floods in the Northwestern United States. Hannoversch-Münden, Int. Assoc. Sci. Hydrol. 48:30-39.

A regression model was used to isolate meteorologic, topographic, and geologic causes of floods; covariance analysis was used to determine forest effects, variation in forest effects with respect to watershed size, storm size, and geology. Results showed that clearcutting and forest fires have increased floods from watersheds in the Northwestern United States.

(120) Berndt, H. W.
1971. Early effects of forest fire on streamflow characteristics. USDA For. Serv. Res. Note PNW-148, 9 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"A comparison of streamflow records from three small mountain streams in north-central Washington before, during, and after a severe forest fire showed three immediate effects of destructive burning. These were:

"Flow rate was greatly reduced while the fire was actively burning.

"Destruction of vegetation in the riparian zone reduced diurnal oscillation of flow rates.

"Flow rates quickly increased to points above protracted normal depletion rates but to varying degrees.

"No drastic immediate change in stream temperatures was noted."

(121) Berndt, H. W., and G. W. Swank
1970. Forest land use and streamflow in central Oregon. USDA For. Serv. Res. Pap. PNW-93, 15 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

"In this case study, the hydrologic performance of a 295-square-mile drainage in central Oregon was compared with the land use history for the period 1921-65. Two distinct changes in streamflow regimen were identified. The first, beginning about water year 1942, was an increase of 2.21 inches in average annual yield. The timing of this increase is approximately coincident with the onset of timber harvesting activity in the basin. The second change was a decrease of 1.18 inches in average water yield beginning about 1958. This change could possibly be related to the full stocking of cutover lands by dense, second-growth stands and a general reduction of timber harvest activity.

"Though more sensitive, refined tests of the influence of timber harvest on water yield are needed for stands east of the Cascade Range, the analyses in this report show that accepted management practices for vegetative types found on Ochoco Creek have favored water yields."

(122) Dunford, Earl G.
1960. Logging methods in relation to streamflow and erosion. 5th World For. Congr. Proc. Vol. 3, Sec. VII, p. 1703-1708. Seattle, Wash.

Various steps in logging operations and their effects on streams and soil are discussed. An "undisturbed" strip of land between a stream and parallel logging roads is recommended.

(123) Ferrell, W. K.
1960. The control of stream flow and water quality through timber harvesting. *In* E. F. Eldridge [ed.], Water problems of the Pacific Northwest. 7th Symp. Water Pollut. Res. Proc., p. 45-47. U.S. Public Health Serv., Reg. IX, Portland, Oreg.

The effects of timber harvesting on stream flow and water quality are discussed. The author also discusses the idea that forest harvesting practices of various kinds can be compatible with watershed management if these practices are carefully planned and controlled.

(124) Gangmark, Harold A., and Richard G. Bakkala
1958. Plastic standpipe for sampling streambed environment of salmon spawn. U.S. Fish & Wildl. Serv. Spec. Sci. Rep., Fish. 261, 21 p.

"Knowledge of prevailing conditions of streams for spawning salmon can lead to improved management of these streams and improved production of salmon. All-important to the salmon is the condition of the streambed, based both as the characteristics of seepage rate and on the availability of oxygen at spawn depth. At Hill Creek, California, the most feasible method for procuring this information is by using the standpipe system. This paper describes the design of the Hill Creek standpipe and its method of operation, discusses the mechanics of seepage, and compares the data obtained with data on survival of king salmon spawn."

(125) Harper, Warren Charles

1969. Changes in storm hydrographs due to clearcut logging of coastal watersheds. 116 p. M.S. thesis, Oreg. State Univ., Corvallis.

"The purpose of this study was to determine the effect of clearcut logging on stormflow by analysis of characteristic parameters of individual storm hydrographs. Parameters considered included height-of-rise, peak discharge, volume and time-to-peak. The hydrologic data were derived from experimental watersheds of the Alsea Study located in the Oregon Coast Range.

"Three clearcut watersheds were selected for study; Deer Creek IV (39 acres) was clearcut, and Needle Branch (175 acres) was clearcut and burned. Both watersheds were compared to Flynn Creek (502 acres), and untreated control, before and after treatment.

"Change in hydrologic parameters was determined from differences between pre- and post-logging linear regressions. Statistical techniques were utilized to test for difference in slope or vertical position.

"Significant increases were found in peak discharge from both Needle Branch and Deer Creek IV following clearcut logging. Larger increases were noted during the fall period than during the winter period. Volume parameters of quick flow, delayed flow, and total flow were increased for Needle Branch. Volume of flow was not shown to increase from Deer Creek IV. This may have been due to a lack of usable storm events for analysis from this watershed. Time-to-peak was not altered in Needle Branch but was decreased for low flows and increased for high flows on Deer Creek IV. The height-of-rise parameter did not prove to be of value for detecting change in this study. Comparison of the burned watershed (Needle Branch) to the unburned watershed (Deer Creek IV) did not produce a noticeable difference in any of the parameters.

"The observed changes in stormflow were related to clearcut logging and the effect of vegetative removal on watershed response."

(126) Hibbert, Alden R.

1967. Forest treatment effects on water yield. *In* William E. Sopper and Howard W. Lull [eds.], Forest hydrology, p. 527-543. Oxford: Pergamon Press.

"Results are reported for thirty-nine studies on the effects of altering forest cover on water yield. The studies reveal that forest reduction increases water yield, and that reforestation decreases water yield. A practical upper limit of yield increase appears to be about 4.5 mm/year for each percent reduction in forest cover, but most treatments produce less than half this amount. There is strong evidence that

in well-watered regions, streamflow response is proportional to reduction in forest cover. Streamflow response to treatment is variable; response in streamflow may be almost immediate or considerably delayed, depending upon climate, soils, topography, and other factors."

(127) Hoover, Marvin D.
1952. Water and timber management. J. Soil & Water Conserv. 7(2):75-78.

Research on the relationship between forest cover and streamflow reveals that streamflow is significantly increased by removing trees growing along streams.

(128) Hoyt, W. G., and H. C. Troxell
1932. Forests and streamflow. Am. Soc. Civ. Eng. Proc. 56:1039-1066.

"Two adjacent tracts in the Wagon Wheel Gap area, Colorado, were studied for eight years in the forested state and seven years following the deforestation of one tract. Some of the results are:

"1. The total runoff increased an average of 15% in the deforested area.

"2. About 52% of this increase occurred in nonflood periods.

"3. The maximum daily discharges increased an average of 48% in the deforested tract.

"4. The summer runoff showed an average annual increase of 12% in the deforested area. The average minimum flow increased 12%.

"5. Deforestation produced no appreciable change in minimum winter flows.

"6. Erosion increased about eightfold in the deforested area, although always remained slight.

"7. The mean annual temperature of the deforested area increased 1.3° F."

(129) Hsieh, Frederic Shu-Kong
1970. Storm runoff response from roadbuilding and logging on small watersheds in the Oregon Coast Range. 149 p. M.S. thesis, Oreg. State Univ., Corvallis.

"The effects of roadbuilding, logging and burning upon stream runoff responses to individual storms are evaluated for the Alsea experimental watersheds, located in the Oregon Coast Range. The parameters analyzed are peak discharge, induced peak discharge, time-to-peak, and storm-runoff volume. The volume parameter is further sub-divided into total, quick, delayed, rising limb and falling limb flows. The control-watershed approach and linear regression method are utilized in this study.

"Calibration of the main stations at Flynn Creek (502 acres) and Deer Creek (750 acres) started in 1958. That for subwatershed DC II (138 acres) and DC III (100 acres) started in 1962. Watershed treatments included differing amounts of roadbuilding in the summer of 1965 and logging in 1966. The percentages of each watershed area subject to roadbuilding and to logging, respectively, were: Deer Creek main station, 3.7% and 26% of area in roads and logging, respectively, DC II, 3.1% and 20%, and DC III, 12.1% and 72%. One small portion on the main watershed also received burning treatment in 1967. Flynn Creek was preserved in its natural state as a control. Data were analyzed through 1968.

"The storm-runoff responses of the treated watershed were found to relate to the type of treatment applied and percent of area treated. Roadbuilding resulted in significant increases in peak and induced peak discharges on DC III, which was subjected to the most intensive treatment. Logging generally demonstrated a more pronounced effect on runoff than did roadbuilding, since more vegetation was removed. Although highly significant augmentations in peak and induced peak discharges were detected after logging on subwatershed III, only minor changes were observed at the main Deer Creek outlet.

"The time-to-peak parameter was generally not affected by the land manipulations in this study.

"Separation of the annual data into the assumed recharging and recharged periods, based on antecedent soil moisture conditions, was selected for seasonal comparison over the use of an arbitrary cutoff date.

"Changes in flow volume parameters due to roadbuilding were insignificant. Rising limb flow on DC III as well as at the Deer Creek main station was moderately increased after logging. Although an increase in delayed flow and a decrease in quick flow occurred at the main station, these are considered to be compensating errors.

"Effects on design floods after treatments were indicated by the sharp increases in peak discharges, based upon flood frequency and statistical analyses."

(130) Jeffrey, W. W.
1968. Forest harvesting and water management. For. Chron. 44(6):5-12.

"Forest harvesting affects water management. Total water yield, flow regime and water quality are affected. Usually, in Western Canada, these effects -- whether for good or ill -- are accidental and are not taken into consideration in management. This is at least partly due to resource management people being resource oriented (technocentric) rather than society oriented (democentric) in their attitudes. Forest harvesting-water management interactions represent a technical problem of ultimate social importance. To cope with this problem requires coordination of resource uses, improved communication and administrative

organization, more democentricity, expanded research into socio-economic factors, more attention to long-term environmental goals, examination of land tenure systems, more land use planning, re-orientation of resource management education, a broadening of social conceptual awareness, and increased professional staffing."

(131) Kovner, Jacob L.
1957. Evapotranspiration and water yields following forest cutting and natural regrowth. Soc. Am. For. Proc. 1956: 106-110.

"The experiment has shown that in the high-rainfall belt of the southern Appalachians cutting down all vegetation on a well-forested watershed produced very large increases in streamflow. These increases accompanying regrowth of the forest stand following clear-cutting were remarkably well defined and showed dynamic relationship between vegetation and streamflow, which could be expressed as a linear function of the logarithm of the time variable. Practically all the increase in streamflow came from the base flow or groundwater.

"The results obtained using paired watersheds were verified by use of the water-balance equation for the treated watershed. The increase in streamflow each year was due to a corresponding real decrease in the amount of evapotranspiration. Annual losses to the atmosphere are quite constant for the Coweeta watersheds because of the high rainfall. This accounts for the fact that the increases in streamflow were statistically independent of the annual precipitation for the range experienced--from 56 to 89 inches. It should be noted in this connection that the rainfall was not low for a series of years.

"Heavy sprout and herbaceous growth sprang up and re-covered the area with surprising speed. Tests show that in the 13th year total annual foliage production, by oven-dry weight was not significantly different from that of the control watershed. At the end of the 12th year the basal area per acre was 51.6 square feet, or approximately 50 percent of the projected normal stand. The original relatively all-aged stand was replaced by an even-aged stand with essentially a 6-inch diameter limit."

(132) McGuinness, J. L., and L. L. Harrold
1971. Reforestation influences on small watershed streamflow. Water Resour. Res. 7(4):845-852.

"Analysis of flow duration curves showed that reforestation of a 44-acre watershed near Coshocton, Ohio, reduced flow in the low flow tail of the curve but did not significantly reduce flows above 0.25 inch per day. Other analyses showed that reductions also occurred in the maximum annual flow volumes for all periods of flow durations of 1 day or longer. The onset of dormant season flow was significantly delayed."

(133) Martin, Iury L., and E. Roy Tinney
1962. Logging in west coast watershed shows no effect on area's water yield. Timberman 63(5):46-48.

The data from the study of the Nasselle River watershed show that logging has had a negligible influence on the area's water yield and base flow.

(134) Pollard, R. A.
1955. Measuring seepage through salmon spawning gravel. J. Fish. Res. Board Can. 12(5):706-741.

"The rate of oxygen supply to salmon eggs incubating in a streambed depends on the oxygen concentration in the ground water [intragravel water] and the rate of seepage through the redd. Wickett... devised a simple field method of both sampling the ground water for the determination of its dissolved oxygen content and measuring the seepage rate, using one tool, a standpipe. The theory of seepage is outlined to show the factors governing the velocity of flow through a redd. Alternative ways of measuring this velocity were examined; the best one is a modification of Wickett's procedure using a similar standpipe. A new field procedure for measuring the oxygen concentration and ground water seepage rate in a streambed is recommended."

(135) Reinhart, K. G., and A. R. Eschner
1962. Effect on streamflow of four different forest practices in the Allegheny Mountains. J. Geophys. Res. 67(6):2433-2445.

"After a 6-year calibration, four watersheds in the Fernow experimental forest in West Virginia were logged during 1957-1958. Practices ranged from a commercial clearcutting with "logger's choice" skid roads to a light selection cutting with planned skid roads on moderate grades. For the most part, the treatments did not seriously disturb the forest floor. Annual flow increased up to 5 area-inches on the clearcut watershed the year after treatment. Increases fell into a logical pattern with volume cut. Most of the increase came in the growing season; from May to October 1959, increases were 3.0, 1.8, 1.4, and 0.3 area-inches for per-acre cuts of 8.5, 4.2, 3.7, and 1.7 thousand board feet, respectively. Low flows were augmented, especially for the two heavily cut watersheds. Effect on high flows was variable; on the clearcut watershed some storm-period flows in the growing season were more than doubled, whereas some snow-melt flows were less than expected. Care in the logging operation was clearly reflected in water quality; maximum turbidities ranged from 56,000 ppm on the watershed having unplanned skid roads and no provision for drainage to 25 ppm on the watershed having carefully planned skid roads. Effects of treatment are diminishing with passage of time."

(136) Rothacher, Jack
1965. Streamflow from small watersheds on the western slope of the Cascade Range of Oregon. Water Resour. Res. 1(1):125-134.

"Streamflow from small watersheds on the western slopes of the Oregon Cascade Range is strongly influenced by a maritime climate (wet winters and dry summers). Although annual precipitation is high (94 inches in the study area), overland flow is almost unknown. Peak flows result largely from subsurface flow and under conditions in which both retention and detention reservoirs are almost filled during extended periods of low-intensity rainfall. Under these conditions, vegetation appears to exert a minimum influence on high streamflow. Lowest streamflow occurs from late August to mid-November and may follow a 60- to 100-day period with little or no rain. The dense vegetation of this part of the Douglas-fir region appears to exert its major influence at such times. Removal of vegetation from only 30% of a 250-acre watershed has caused a 12-28% increase in minimum streamflow. On a 237-acre watershed on which 80% of the trees were cut, the increase in low flow was 85%."

(137) Rothacher, Jack
1970. Increases in water yield following clear-cut logging in the Pacific Northwest. Water Resour. Res. 6(2):653-658.

"Increases in water yield following timber harvest roughly conform to the proportion of the area cleared. In high precipitation areas of the Oregon Cascades, clear-cut logging can increase annual water yield 18 inches. Approximately 80% of the increase occurs during the October to March season."

(138) Rothacher, Jack
1971. Regimes of streamflow and their modification by logging. *In* James Morris [ed.], Proceedings of a Symposium--Forest land uses and stream environment, p. 40-54. Oreg. State Univ., Corvallis.

"Streamflow in the Pacific Northwest is most strongly influenced by the precipitation pattern, somewhat less by evapotranspiration losses. Evaporation and transpiration are strongly influenced by logging. Logging and burning old-growth Douglas-fir forests on an experimental watershed increased annual yields of streamwater by 18 inches or more. Most of the increase occurred in fall and winter months. We can't positively attribute any great increase in major 'wet mantle' flood flows to logging in west slope forests. Logging which removes transpiring vegetation increases lowest summer streamflow. Such increases may be short lived as vegetation rapidly invades the cutover areas."

(139) Rowe, P. B.
1963. Streamflow increases after removing woodland-riparian vegetation from a southern California watershed. J. For. 61(5):365-370.

"A test of applied watershed management on the San Dimas Experimental Forest in southern California has shown that streamflow yields can be appreciably increased. This was accomplished by clearing the deep-rooted woodland-riparian vegetation from selected canyon bottom reaches of Monroe Canyon, a typical southern California mountain watershed. The increases in flow were especially important because they occurred primarily in summer and in the initial period of soil wetting during succeeding rainy seasons, when streamflow was lowest and water most needed. During the one rainy season of heavy precipitation and continuously wet soils the removal of the woodland-riparian vegetation had no appreciable effect on streamflow, peak discharge, or erosion rates. However, during wetting periods and during the one rainy season of light precipitation, streamflow yields, particularly during storms, were considerably increased. Streamflow was inadequate to produce sediment movement in either the treated or control watersheds during these wetting periods. Removal of the tree-brush cover shading the stream course resulted in an increase in the algae content of the late spring and summer flows but had no other detectable effect on water quality. These first results show that, while streamflow can be increased by removal of the canyon bottom vegetation, this kind of treatment, to be most successful, should be limited to carefully selected areas with conditions of climate, vegetation, soil, and water capable of yielding the desired increases. That is, to areas in which (1) the water supply is adequate to exceed evapo-transpiration losses after treatment, (2) the water table or zone of saturation is within reach of the heavy water using woodland-riparian vegetation, and (3) the canyon bottom soils overlaying the water table are of sufficient extent and depth to permit reduction in evapo-transpiration if the deep-rooted vegetation is eliminated."

(140) Sartz, Richard S.
1951. An objective look at the vegetation-stream flow relationship. J. For. 49(12):871-875.

The important factors involved in the precipitation-vegetation-soils streamflow relationships are discussed.

(141) Terhune, L. D. B.
1958. The MARK VI groundwater standpipe for measuring seepage through salmon spawning gravel. J. Fish. Res. Board Can. 15(5):1027-1063.

Procedures of the MARK VI standpipe method for measuring gravel permeabilities and velocities are described. This method incorporates new procedures to the Pollard (*134*) method of measuring permeabilities and increases the range of permeability measurements from 100 to 100,000 cm/hr and velocity measurements from 5 to 200 cm/hr with less than 10 percent error. Complete details of design, construction, and procedure for use in salmon spawning gravels are given.

(142) Vaux, Walter G.
1962. Interchange of stream and intragravel water in a salmon spawning riffle. U.S. Fish & Wildl. Serv. Spec. Sci. Rep., Fish. 405, 11 p.

"Dissolved oxygen is supplied to intragravel water in a salmon spawning riffle through (1) interchange of water from the stream into streambed gravel, and (2) ground-water flow. The primary variables that control interchange are gradient in the stream profile, permeability of the gravel bed, and dimensions of the bed.

"The delivery of dissolved oxygen to intragravel water and the way in which rate of delivery is affected by stream profile, permeability, and dimensions of the bed are explained.

"The dissolution of oxygen through the air-water interface in turbulent stream water is rapid. This is shown by the near-saturation oxygen level in surface water of unpolluted streams."

(143) Zach, L. W.
1950. Effect of rainfall on stream flow in southeast Alaska. USDA For. Serv. Tech Note 4, 3 p. Alaska For. Res. Cent., Juneau, Alaska.

The study has shown that southeastern Alaska salmon streams are characterized by marked fluctuations in flow and recurring fall floods. In the fall rainy season, violent floods move log jams and gravel bars and produce minor changes in the stream channels.

DESCRIPTIONS OF EFFECTS OF LOGGING STUDIES

(144) Bureau of Commercial Fisheries
1963. Review of research on effects of logging on pink salmon streams in Alaska. Fish & Wildl. Serv., 18 p. U.S. Dep. Inter. Bur. Comm. Fish. Biol. Lab., Auke Bay, Alaska.

The long-term study of the effects of logging on Alaskan pink salmon spawning streams is reviewed. The research objectives, methods of research, and achievements of the study and the specific problems which should be investigated in future studies are covered.

(145) Calhoun, Alex
1962. A long look at logging. Outdoor Calif., Nov. p. 7-10.

Poor logging practices in California and some of the efforts to correct these problems are discussed. The article states that there are two major problems: (1) log jams, which block migrating salmonids, and (2) sedimentation, which smothers stream gravels, thus producing less food and fewer young fish by hatching fewer eggs and producing fewer places for small fish to hide.

(146) Campbell, Homer J.
1970. Fish, forests and water. Oreg. Game Comm. Bull., July, p. 3-6.

The problems of resource managers and the results of improper logging are discussed. Briefly described are some of the studies the State of Oregon has conducted and some of the results.

(147) Chapman, D. W.
1962. Effects of logging upon fish resources of the west coast. J. For. 60(8):533-537.

The author reviews the effects of logging on fish. It was found that after logging:

"1) stream runoff was increased and as a result of heavy run-off gravel shifting occurred;

"2) summer temperatures increased and winter temperatures decreased;

"3) chemical quality of water deteriorated;

"4) sediment increased;

"5) stream energy source was disrupted; and

"6) barriers to fish migration were left."

A good bibliography is included.

(148) Cordone, Almo J.
1956. Effects of logging on fish production. Calif. Fish & Game, Inland Fish. Adm. Rep. 56-7, 98 p. [Mimeogr.]

"The material examined consisted of published and mimeographed literature, regulations and policies, and correspondence. No attempt was made to compile a complete bibliography. However, it is believed that the more important published and mimeographed literature was reviewed. The subject of pollution from sawdust and sulfite liquor wastes was not covered. The physical influences of logging on the environment were stressed, i.e., soil erosion, turbidity, sedimentation, fluctuating stream flows, etc. Material on direct effects of logging on fish life was rare, but papers concerning the foregoing factors were common. That these factors are interrelated with fish production is universally accepted.

"The report is divided into three parts: (1) review of literature, (2) review of regulations and policies, and (3) list of literature not examined. The first part is presented in the form of an annotated bibliography. Direct quotes are employed as annotations whenever feasible. This eliminates some subjective interpretations. A brief summary of the surveyed material is presented at the end of the report."

(149) Fisheries Research Institute
1959. Logging and salmon. Fish. Res. Inst. Circ. 105, 12 p., Univ. Wash., Seattle.

A booklet to acquaint the reader with some of the techniques and results of studies by the Fisheries Research Institute at Hollis, southeast Alaska.

(150) Hall, James D.
1967. Alsea watershed study. Oreg. State Univ., Dep. Fish. & Wildl. Pam., 11 p. Corvallis.

The pamphlet is a guide to the Alsea study area and an outline of the research underway to determine the effects of logging on aquatic resources. Areas of research include: (1) hydrologic studies; (2) soil-vegetation survey; (3) streamflow, sediment, and water temperature; (4) chemical and bacteriological water quality; and (5) fishery studies. The pamphlet presents some initial results from the study.

(151) Harris, A. S.
1961. The physical effect of logging on salmon streams in southeast Alaska. [Abstract.] 11th Alaskan Sci. Conf. Proc. 1960:143-144.

The physical effects of logging on salmon streams are discussed. Results show that more basic research is needed on the physiological requirements of salmon eggs and alevins before man can evaluate the physical effects or changes of logging on salmon.

(152) Lantz, Richard L.
1967. An ecological study of the effects of logging on salmonids. 47th Annu. Conf. West. Assoc. State Game Fish Comm. Proc. 1967: 323-335.

The Alsea watershed study and some of its findings concerning the effects of logging on fish populations are outlined. The objective of the study was to evaluate and compare the effects of two patterns of timber harvesting. The study included an examination of fish population, stream environment, intragravel environment on salmonid survival to emergence, streamflow, stream temperature, and suspended sediment.

(153) Lantz, Richard L.
1970. Effects of logging on aquatic resources. *In* H. J. Rayner, H. J. Campbell, and W. C. Lightfoot [eds.], Progress in game and sport fishery research...1963-1970, p. 13-16. Rep. Res. Div. Corvallis: Oreg. State Univ.

The work carried out by Oregon State University on the Alsea watershed in Oregon is summarized. Primary changes observed on the aquatic environment due to logging were (1) an increase in stream temperature, (2) a decrease in dissolved oxygen levels in surface waters during summer when logging debris was present, (3) a decrease in intragravel dissolved oxygen levels and in the permeability of the intragravel environment when salmon embryos were present in the stream, (4) an increase in suspended sediments, and (5) a decrease in the cutthroat trout populations.

(154) Narver, David W.
1971. Carnation Creek watershed study. Fish. Res. Board Can. Biol. Stn., 7 p. Nanaimo, B. C., Can. [Mimeogr.]

"There is little scientific information about the impact of current logging and reforestation methods on the productive capacity of salmon and trout streams in British Columbia. Long-term watershed studies, including years before, during and after logging, are required. An unknown but presumably large portion of the coho salmon production in British Columbia is from small streams. The rate of deforestation (usually meaning clear-cutting and burning to the stream margin) is accelerating, and probably the small streams are most susceptible to damage. Small salmon nursery streams without lakes in the watershed to provide some flow control, are common along the British Columbia coast. Thus the study being implemented on Carnation Creek should have rather broad application on much of Vancouver Island and the coastal mainland.

"The purpose of this document is to provide information to government, university and industry personnel about the Carnation Creek watershed study that is being conducted cooperatively by certain agencies of the new Federal Department of the Environment and MacMillan Bloedel Ltd. The possibility of participation by other organizations is emphasized."

(155) Phillips, Robert W.
1963. Effect of logging on aquatic resources. Oreg. State Game Comm., Res. Div. Rep., p. 105-122. Portland.

The study conducted in the Alsea watershed was primarily concerned with measuring the effect of logging on the production and yield of silver salmon and steelhead. The aim of the investigation was to determine (1) the effect of a gravel environment on survival and (2) the effect of logging on the environment. This preliminary report covers the effect of the environment on survival and includes a discussion of (1) dissolved oxygen and apparent velocity versus emergence, (2) dissolved oxygen versus emergence, (3) gravel size versus emergence, (4) dissolved oxygen content of intragravel water, and (5) gravel permeability.

(156) Phillips, Robert W., Homer J. Campbell, Wayne L. Hug, and Errol W. Claire
1966. A study of the effects of logging on aquatic resources, 1960-1966. Oreg. State Game Comm., Res. Div. Prog. Memo. Fish. 3, 28 p. Corvallis: Oreg. State Univ.

The scope, methods, and techniques of a logging study are outlined; and some of the initial effects and specific problem areas encountered are presented.

(157) Sheridan, William L., and William J. McNeil
1960. Effects of logging on the productivity of pink salmon streams in Alaska. *In* Ted S. Y. Koo [ed.], Research in Fisheries, 1959. Coll. Fish. Contrib. 77:16-17. Univ. Wash., Seattle.

The broad plan of the work carried out at Hollis, southeast Alaska, was to define normal patterns before logging so that the changes might be measured as logging progressed. Changes studied were year-to-year escapements of adult spawners, the abundance of downstream migrants, survival rates of eggs and alevins in gravel, distribution and intensity of spawning, and the quality of the environment.

RELATED SALMONID INFORMATION

(158) Au, David Wah Kwai

1972. Population dynamics of coho salmon and its response to logging in three coastal streams. 258 p. Ph.D. thesis, Oreg. State Univ., Corvallis.

"This study examines the ecology and dynamics of coho salmon (*Oncorhynchus kisutch*) in environments experimentally altered by logging. The objective was to evaluate processes that stabilize or regulate the populations.

"Two small watersheds in Oregon's Coast Range were logged in 1966, one clear-cut, the other patch-cut. A third adjacent watershed was left uncut as a control. The influence of these treatments on the biology of the coho was assessed. Attention was concentrated on populations of the six year classes 1963 to 1968.

"The natural variability of streamflow-related conditions influencing both the magnitude and pattern of coho recruitment each year was increased in the logged watersheds. Peak flow during storms increased; intragravel dissolved oxygen levels decreased in the stream draining the clear-cut watershed. These changes, however, were apparently within the range of variation that the coho naturally experience. Increased stream temperatures and mortalities, due to the logging effects, altered the post-recruitment life conditions of the coho in that stream but did not significantly affect the final smolt yield.

. . . . . .

"Adjustments in coho population size were largely accomplished by fall, resulting in stable and characteristic population levels in each stream. A stable smolt yield was a further result. These adjustments are accomplished through high mortality during the months of the first spring and summer. This mortality is likely density dependent and related to the territorial and agonistic behavior of the fish.

"Growth, biomass, and net production varied greatly during each year. Seasonal changes in growth rate resulted in seasonal variations in biomass that were in contrast to the stabilized trends of population number. The pattern of net production rate was also largely determined by the seasonal growth pattern, and like biomass, did not show a tendency to stabilize with time. It averaged 5 g/m^2 among the three streams for the period June 1 to April 15.

. . . . . .

"This study has shown that coho streams normally produce characteristic levels of smolt yield in spite of large natural variations in fry input and conditions for growth. The range of environmental variation for which this result holds may include short-term changes due to

logging. However a normal population response to such a severe altera tion as occurred on Needle Branch is very likely conditional upon a program that at least includes vigorous stream clearance, the restriction of additional mortality to early summer, when population adjustments are far from complete, and the encouragement of streamside revegetation. A streamside buffer strip of trees is an effective way of protecting aquatic resources."

(159) Bakkala, Richard
1964. Abernathy spawning channel proves effective for reproduction of chum salmon. Comm. Fish. Rev. 26(12):20-21.

"With one exception, the environment created in the Abernathy channel has been adequate for the successful incubation of chum salmon eggs. Deposition of sediment from the water supply as it moved through the channel has made it difficult to maintain the original permeable condition of the streambed gravel. Removing and screening the gravel in the channel provided a temporary solution to this problem. A more permanent solution will be attained with a settling basin which will remove silt and sand from the water supply before it enters the channel."

(160) Bjornn, T. C.
1968. Survival and emergence of trout and salmon fry in various gravel-sand mixtures. *In* Richard T. Myren [ed.], Logging and salmon, p. 80-88. Proc. Forum Am. Inst. Fish. Res. Biol., Alaska Dist., Juneau, Alaska.

"The survival and emergence of steelhead trout and chinook salmon were tested in various mixtures of gravel and sand in troughs with flow and gradient control. The emergence of swim-up steelhead trout fry placed in the troughs was reduced by large percentages of sand. Swim-up chinook salmon fry appeared to be more impeded by sand than were steelhead trout, but these results need to be verified because some sick fish were unknowingly included in the test samples. The survival from green egg to emergence of chinook salmon was relatively high (70-77 percent) in gravel with little or no sand but much reduced in gravel with 18 percent or more sand."

(161) Burgner, Robert L.
1960. Spawning and growth of fish. *In* E. F. Eldridge [ed.], Proceedings of 7th symposium on water pollution research, p. 33-3 U.S. Dep. Health, Educ. & Welfare, Reg. IX, Portland, Oreg.

The aquatic environment and its effect on the development and survival of eggs and larvae of pink and chum salmon are discussed with respect to the logging studies conducted by the Fisheries Research Institute in southeast Alaska.

(162) Burns, James W.
1971. The carrying capacity for juvenile salmonids in some northern California streams. Calif. Fish & Game 57(1):44-57.

"Standing crops of juvenile coho (silver) salmon (*Oncorhynchus kisutch*), steelhead rainbow trout (*Salmo gairdneri*), and coast cutthroat trout (*Salmo clarki*) were examined in seven coastal streams to define the natural carrying capacity of these streams, and to develop methods of population comparison and prediction which could be used to determine the effects of road construction and logging on salmon and trout production.

"Biomass per unit of surface area was the best method of expressing carrying capacity, because biomass was better correlated with stream surface area than with other parameters tested. Volume of streambed sediments, total dissolved solids, alkalinity, and total phosphate in six streams were not satisfactory predictors of carrying capacity. Only living-space variables correlated significantly with biomass. Not all streams reached carrying capacity in the summer and salmonid biomass was highly variable. Even with 3 years of prelogging study, it would be difficult to attribute a change in carrying capacity under 50% to anything but natural variation."

(163) Chapman, D. W.
1965. Net production of juvenile coho salmon in three Oregon streams. Trans. Am. Fish. Soc. 94(1):40-52.

"Net production of juvenile coho salmon was estimated in three small streams in Oregon for 4 consecutive years. Annual net production of coho was greatly different in the 4 years, but production per unit area was similar among streams, averaging about 9 g/m^2 per year. No significant differences were found among streams in production per unit area for 14 months from emergence of fry one spring through seaward migration the next spring. For 4 years biomass averaged 5-12 g/m^2 shortly after emergence of fry, declining to 2-3 g/m^2 by July and remaining at about 2-4 g/m^2 until emigration of smolts in the following spring. In all years, mean production declined from 1.9-2.8 g/m^2 per month after emergence to 0.2-0.3 g/m^2 per month in winter, then increased to 0.5-0.6 g/m^2 per month prior to emigration. Monthly instantaneous growth rates were highest shortly after emergence of fry, declining until late winter, then increasing just before smolt emigration. The mean monthly instantaneous growth rate was about 0.19 for all streams and years. Yield of smolts as seaward emigrants ranged from 18 to 67 per 100 m^2. Net production was 1.5 to 3.0 times greater than yield as biomass of smolts. Net production of all fish in one stream containing coho, steelhead and cutthroat trout, and cottids was estimated to be 16 g/m^2 per year and compared with data from other waters. Relatively large freshets appeared

to cause large downstream movements of juvenile coho. Downstream drift of postemergence fry and emigration of yearlings tended to bias estimates of growth and net production in the residual populations."

(164) Coble, Daniel W.
1960. The influence of environmental conditions in redds on the survival of salmonid embryos. 37 p. M.S. thesis, Oreg. State Univ., Corvallis.

Movement of gravel 10 inches below the surface of a streambed was indicated in areas where no logging disturbance was apparent. The survival of salmonid embryos in the gravel was related to the apparent velocity and dissolved oxygen content of subsurface water.

(165) Cooper, A. C.
1959. Discussion of the effects of silt on survival of salmon eggs and larvae. *In* E. F. Eldridge and J. N. Wilson [eds.], Proceedings 5th symposium--Pacific Northwest on siltation--its source and effects on aquatic environment, p. 18-22. U.S. Dep. Health, Educ. & Welfare, Portland, Oreg.

Surface flow over a smooth bed with a constant gradient showed intragravel flow lines nearly parallel with some interchange near the surface. Interchange in the top 1 foot of stratum was increased with the addition of large rocks, and downward interchange occurred when a pile of gravel was formed by a female salmon digging a redd.

(166) Dill, L. M., and T. G. Northcote
1970. Effects of gravel size, egg depth, and egg density on intragravel movement and emergence of coho salmon (*Oncorhynchus kisutch*) alevins. J. Fish. Res. Board Can. 27(7):1191-1199.

"In experimental aquaria with large gravel (3.2-6.3 cm), vertical and lateral movements of coho salmon (*Oncorhynchus kisutch*) alevins were more extensive and area utilized per alevin was greater than in small gravel (1.9-3.2 cm). At low density (50 per aquarium) the alevins moved farther towards the inlet, but the mean area occupied per alevin was the same as that at high density (100 per aquarium). Burial depths tested (20 and 30 cm) had no significant effect on vertical or lateral movements or on area utilized per alevin. Alevin orientation in the gravel, survival to emergence, and timing of emergence were not affected by any of the environmental variables examined."

(167) Dill, Lawrence M.
1969. The sub-gravel behaviour of Pacific salmon larvae. *In* T. G. Northcote [ed.], Proceedings of symposium--Salmon and trout in streams, p. 89-99. Univ. B. C., Vancouver, B.C., Can.

"Results of a study of the sub-gravel behaviour of the coho salmon (*Oncorhynchus kisutch*) are compared with studies of other salmonid

larvae. The present results were obtained through observation of the larvae or alevins in specially designed aquaria. The alevins moved about within the gravel prior to emergence, apparently as a result of phototaxes and rheotaxes, the directions of which varied with the age of the fish. For example, the response to light was initially negative, but changed to positive as the time of emergence approached. Lateral movements were similarly influenced by the current direction.

"There was evidence that the alevins were spacing themselves out within the gravel, and that some interaction was taking place between them. The effects upon behaviour of changes in burial density, burial depth, and gravel size were also explored. Several studies are suggested as logical and productive continuations of the present work, and their implications are discussed from both practical and theoretical standpoints."

(168) Fisheries Research Institute
1960. Observations in Hollis area study streams, fall 1959. Fish. Res. Inst. Circ. 117, 6 p. Univ. Wash., Seattle.

"Our evidence indicates that in the fall of 1959 suspended sediment increased in tributaries to the Harris River and that during the same period streambed sediment increased in the upstream sampling area. Loss of, nor death to, salmon eggs in the intertidal study area as a result of a number of large trees sweeping downriver on high water was not detected."

(169) Gangmark, Harold A.
1963. A view of the present status of spawning channels. Report to 2d Governors' Conference on Pacific Salmon, Convened by Governor Albert D. Rosellini at Washington Hyatt House, Seattle.

"Advantages of improved production (salmon) areas usually include: stabilized stream flow, reduced silt loads, clean gravel, gravel sizes that preclude washout of eggs, and predetermined hydraulic gradients. They can also include temperature regulation of the stream flow below impoundments.

"Disadvantages may include construction and maintenance costs and confinement that might limit the carrying capacity and, in one way, favor predators.

"On a management scale the cost benefit of controlled flow may make such areas of controlled flow for salmon alone prohibitive. When tied in with other benefits, however, it can become feasible. For example, the water conservation and flood control programs that involve practically every stream in California can provide many acres of such control flow for the benefit of salmon."

(170) Gangmark, Harold A.
1962. The mill creek channel study. Presented West. Div. Am. Fish. Soc., Seattle, Washington.

"To learn how we might achieve the conditions desired in our spawning channel, we studied, among other places, the Sacramento River near Red Bluff. In test plants similar to the ones made in Mill Creek, (salmon) egg samples were eroded out of the streambed and lost in four out of five seasons. In the one successful year, in which we were able to measure our results, only 1.7% fry were produced.

"In the fall of 1961, we moved the location of our river studies 40 miles upstream to a riffle near Redding where the tributaries entering the river, do so, below the Redding area.

"Actual survival was 53.6% of the eggs planted or 74.4% of eggs that survived the initial handling and planting operation. As a result of comparing the differences between the Redding and Red Bluff stream sections we found the former had only 1/3 the fines. The streamflow at Redding was stabilized and heat storage in Shasta Reservoir was responsible for moderating and tempering water temperatures."

(171) Gangmark, Harold A., and Robert D. Broad
1955. Experimental hatching of king salmon in Mill Creek, a tributary of the Sacramento River. Calif. Fish. & Game 41:233-242.

"The upper Sacramento River system continued to flood during the last stage of the experiment. The water gauge used by the California State Division of Water Resources was torn from its position by the flood. Records received from the Water Resources Branch of the United States Geological Survey show the Mill Creek rose to 5,240 c.f.s. or approximately 100 times the flow recorded at the time the eggs were planted. The result was that all but six sacks of eggs (salmon) disappeared from the stream bed. Examination of the sacks that could be found revealed that none of the embryos had survived the floods. The shifting of the channel and the eroding and smothering action of silt and sand apparently caused a complete kill of the developing young salmon."

(172) Gangmark, Harold A., and Robert D. Broad
1956. An experiment with Vibert boxes. Prog. Fish. Cult. 18(3):143-144.

"Stream erosion and silting were mentioned as products of flooding which caused damage to (salmon) eggs in nature. In 1954, to explore this subject further, Vibert boxes...were used along with the usual plastic mesh sacks, for incubating eggs. The boxes were to serve as a research tool rather than to prove or disprove the Vibert system.

As Vibert boxes are made from extremely rigid plastic, the writers felt that damage to eggs by stream erosion could be eliminated.

"It had been supposed that use of the rigid boxes, rather than plastic sacks, would eliminate the grinding, wearing factor of stream erosion; but except for three samples washed downstream, results favored the sacks."

(173) Gangmark, Harold A., and Robert D. Broad
1956. Further observations on stream survival of king salmon spawn. Calif. Fish & Game 42:37-49.

The authors present evidence of a relationship between the occurrence of floods and the reduced survival of salmon eggs.

(174) Gangmark, Harold A., and F. Bruce Sanford
1963. Theory on development of mounds near Red Bluff, California. U.S. Fish & Wildl. Serv., Fish Bull. 63(1):213-220.

"Although the subject of mounds is not directly a part of fishery studies, the agents that we think lead to the formation of mounds - namely, flooding of the stream and erosion of soil materials - also kill salmon by scouring the stream gravel or depositing silt in the streambed. This action destroys incubating spawn by removing gravel and washing out eggs and by depositing silt and subsequently smothering the eggs. Similarly, larvae and other aquatic forms that the salmon fry eat are either washed out or the habitat of these forms is destroyed by deposition of silt, and the food supply for the young salmon is greatly diminished."

(175) Graves, David S., and James W. Burns
1970. Comparison of the yields of downstream migrant salmonids before and after logging road construction on the South Fork Caspar Creek, Mendocino County. Calif. Fish & Game, Inland Fish. Adm. Rep. 70-3, 11 p.

"Yields of juvenile steelhead rainbow trout (*Salmo gairdnerii gairdnerii*) and silver salmon (*Oncorhynchus kisutch*) emigrants were compared in South Fork Caspar Creek, a small coastal stream in Mendocino County, California, before and after construction of a logging road along the stream in the summer of 1967. Numbers, lengths, and age class structures were compared.

"There were 138% more steelhead smolts and 41% fewer silver salmon smolts in 1968 (first spring following road construction) than there had been in 1964 (preroad construction). Increased emigration of steelhead smolts in 1968 was probably caused by a decrease in favorable living space. The decrease in salmon smolts accompanied high mortalities

during road construction. Eighty-three percent of the total salmon population and 86% of the total steelhead population died or emigrated from the affected area during the road construction from June to October 1967. The combined populations of steelhead and salmon smolts decreased 20%. This combined decrease is within the range of natural fluctuation reported from other California streams; however, there is no doubt that road construction contributed to the decrease in Caspar Creek.

"Steelhead and salmon fry were more numerous in 1968 than in 1964. No steelhead fry were trapped in 1964, while 72% of the migrants trapped in 1968 were fry. The age composition of the salmon also shifted markedly from 1964; fry comprised 5% of the total in 1964 and 81% in 1968. This increase in numbers of emigrating fry in 1968 could have resulted from poor environmental conditions.

"Steelhead smolts were smaller in 1968 than in 1964, while salmon smolts were larger. Salmon fry were smaller in 1968. Steelhead fry cannot be compared as none was trapped in 1964. The increase in length of the salmon smolts may have resulted from a decrease in competition due to higher mortality in 1967. The fry may have been smaller due to unfavorable intragravel conditions during incubation. Comparison of steelhead smolts is difficult because of the emigration of more than one year class. The decrease in average length, however, supports the hypothesis of premature emigration due to unfavorable habitat."

(176) Hanzel, Delano A.
1961. Inventory of the waters of the project area. Northwest Mont. Fish. Stud. Mont. Fish & Game, Fish. Div. Fed. Aid in Fish Restoration, Job Completion Rep., Proj. F-7-R-10, 9 p. Helena, Mont.

"Seven lakes and four of the principal tributaries in the Stillwater River Drainage were surveyed. Netting series on the lakes indicated a predominance of pumpkinseeds, largescale suckers, northern squawfish, and redside shiners. Electrical censusing of the tributaries show a predominance of cutthroat trout, brook trout and Dolly Varden. Physical barriers block fish movement up the major tributaries.

"Surveys of five lakes in the South Fork of the Flathead River Drainage were conducted during the report period. Data is presented as a record of present fish populations and composition in a remote wilderness area. The majority of cutthroat trout collected and checked in creels from the South Fork River and tributaries were in the III and IV age groups (ave. 9.4 inches). Fish measured on the Middle Fork River and tributaries averaged 1.3 inches smaller than those taken in the South Fork Drainage. Estimated 1960 use of the Bob Marshall Wilderness Area (including both South and Middle Fork Drainages), west of the Continental

Divide, was 3,990 people (Summer - 2,190; Fall - 1,800). There is a total of 80 established camp sites in the wilderness area. Summer use is primarily (64 percent) non-guided parties.

"A survey of the fish populations and physical stream characteristics were continued on Pinkham Creek in order to establish the effects of logging on a fish population. Timber has now been cut on 30 percent of the 39,300 acres within the drainage. Three of the eight sections previously censused were electrically fished. A total of 250 brook trout weighing 9.55 pounds and 170 rainbow trout weighing 10.63 pounds were collected. The number and weight of all fish in 1960 was greater than taken from these three sections in any previous year (1951-56)."

(177) International Pacific Salmon Fisheries Commission
1966. Effects of log driving on the salmon and trout populations in the Stellako River. Int. Pac. Salmon Fish. Comm. Prog. Rep. 14, 88 p.

"Field and laboratory investigation of effects of log driving on the fish populations of Stellako River were carried out during 1965. Field studies showed that log jams caused damage to approximately eight per cent of sockeye spawning grounds by erosion of gravel and bark deposition. That the damage was real was verified through analysis of subsequent spawning distribution which showed that spawners tended to avoid the damaged areas. Laboratory results indicated that moderate gravel disturbance due to erosion and gouging by individual logs could also have killed incubating trout eggs in Stellako River, but that vertical impact on the gravel surface would have caused only occasional mortality."

(178) Johnson, B. W., E. M. Miller, and C. H. Ellis
1952. A report on steelhead egg and fry survival experiments on the North Fork of Stillaguamish River with relation to the North Fork earth slide. Unpubl. rep., Wash. State Fish. Dep., Olympia.

"The silting of the slide in the Stillaguamish River has a very definite effect on development of eggs and fry for a limited distance of less than one mile below the slide and in that area causes 50% to 100% loss of eggs and fry.

"From one mile to five miles below the slide no significant difference could be observed in loss of eggs and fry from silting effects [a 33.5% survival].

"Comparing survivals from a distance of one mile or more below the slide and survivals above the slide a very maximum of 10% loss to eggs and fry could be assessed to silting of the river. [Authors buried steelhead eggs in plastic sacks in gravel.]"

(179) Kabel, C. S., and E. R. German
1967. Caspar Creek study completion report. Calif. Fish & Game Mar. Res. Admin. Rep. 67-4, 27 p.

This study included the effects of logging on Caspar Creek and its population of silver salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdnerii*). The information on both species includes behavior of adults and young population, counts, length frequencies, and length-weight and length-fecundity relationships. The report recommends that similar experiments be made on two tributary streams entering the ocean rather than on two forks of a single stream. It also suggests that these tributaries be larger than the individual forks of Caspar Creek.

(180) McKernan, Donald L., Donald R. Johnson, and John I. Hodges
1950. Some factors influencing the trends of salmon populations in Oregon. Trans. North Am. Wildl. Conf. 15:427-449.

"Three factors were found to be significantly correlated with the fluctuations and trends in silver salmon production in Oregon.

"(1) Logging was found to adversely affect the runs of salmon in later years. A significant negative correlation was found between the trend of logging in one coastal watershed studied and the abundance of silver salmon (as measured by the catch) in the river two cycles or six years later.

"(2) Exceptional winter floods and low summer water flows seem to produce poor runs.

"(3) The intensity of fishing was also found to affect the subsequent productivity of the fisheries.

"Other factors studied did not bear on significant relationship to the fluctuations or trends of productivity of silver salmon."

(181) McNeil, William J.
1964. Environmental factors affecting survival of young salmon in spawning beds and their possible relation to logging. U.S. Fish & Wildl. Serv., Bur. Comm. Fish. Manuscr. Rep. 64-1, 25 p. Auke Bay Biol. Lab., Auke Bay, Alaska.

"In this report, an attempt has been made to review some of the factors influencing survival of salmon embryos and alevins which conceivably may be influenced by logging. The review has not been exhaustive, but an attempt has been made to include the more pertinent recent work which has come to the author's attention. It is possible to make some conclusions on the basis of this review.

"Results of field studies have revealed that extrinsic environmental factors have an important bearing on the survival of young

salmon in spawning beds. The data indicate that increased mortality may occur during periods of minimum and maximum flow of streams, when debris shifts position in stream channels and when permeability of spawning beds is reduced by the presence of fine particulate matter. It is conceivable that logging could exert both harmful and beneficial influence on young salmon in spawning beds. Harmful effects might include increased maximum flows of streams, more debris in stream channels, and more settleable solids transported into spawning streams. A beneficial effect might result should logging cause the minimum flows of streams in Southeastern Alaska to increase. It is apparent that the addition of silt and debris to streams should be avoided and the stability of stream banks should be preserved whenever possible.

"Solution of the salmon-logging problem lies ultimately in the economic development of watersheds and streams for the benefit of both resources. In this regard, some initial efforts have been made on improvement of natural spawning beds in Alaska...and more work is planned or underway. But even in the area of spawning bed improvement there is a great need to obtain a more detailed understanding of the biological and physical factors that control fry production from spawning beds. Hence, the natural processes that control fry production from salmon spawning beds must be well understood before a satisfactory evaluation or solution of the salmon-logging problem can be achieved."

(182) McNeil, William J.
1966. Effect of the spawning bed environment on reproduction of pink and chum salmon. U.S. Fish & Wildl. Serv., Fish. Bull. 65(2):495-523.

"Mortality of 5 brood years of pink salmon, *Oncorhynchus gorbuscha*, and chum salmon, *O. keta*, in spawning beds of three Southeastern Alaska streams was studied. Eggs and larvae were sampled periodically, and mortality was associated with certain environmental factors: The supply of dissolved oxygen, the stability of spawning beds, and freezing.

"Total mortality between spawning and fry emergence typically varied between 75 and 99 percent in the study areas. High mortality occurred during low and high stream discharge and freezing air temperatures. Mortalities ranging from 60 to 90 percent of deposited eggs occurred in association with low dissolved oxygen levels during and after the spawning period. Movement of gravel in certain instances was associated with the removal of 50 to 90 percent of eggs and larvae present in spawning beds. Freezing caused up to 65 percent mortality of eggs and larvae in one stream.

"Low dissolved oxygen levels occurred once in 5 years. This occurrence was associated with unusually low water during spawning in

late summer. Mortality during periods of heavy precipitation was highly variable. In one instance, a 90-percent mortality occurred where wood debris was deposited within the high water channel. Wood debris floating over spawning beds was not damaging to eggs and larvae. There were several instances where mortality estimated at almost 50 percent occurred with no evidence that deposited wood debris shifted position. High mortality from freezing occurred only in the stream having the lowest minimum discharge."

(183) McNeil, William J.
1968. Effect of streamflow on survival of pink and chum salmon in spawning beds. *In* Richard T. Myren [ed.], Logging and salmon, p. 96-114. Proc. Forum Am. Inst. Fish. Res. Biol., Alaska Dist., Juneau, Alaska.

Studies conducted in southeast Alaska revealed the following:

"1. Low streamflow in summer causes low levels of dissolved oxygen in intragravel water and high mortality of pink and chum salmon spawn.

"2. Freezing can cause high mortality of pink and chum salmon spawn where streamflow fluctuates drastically. Spawn in streams with relatively stable streamflow which varied less than 100-fold between average daily minimum and maximum discharge experienced low mortality in cold winters.

"3. Eggs and alevins of pink and chum salmon are highly vulnerable to dislodgment from spawning beds during high streamflow. The stranding of debris on spawning beds increases gravel movement and mortality.

"4. Increased high streamflow and addition of debris to stream channels from logging would be harmful to pink and chum salmon. Increased low streamflow would be beneficial."

(184) McNeil, William J., and W. H. Ahnell
1964. Success of pink salmon spawning relative to size of spawning bed materials. U.S. Fish & Wildl. Serv. Spec. Sci. Rep., Fish. 469, 15 p.

"The potential of a salmon spawning bed to produce fry is directly related to its permeability. The relationship between the coefficient of permeability and the fraction of bottom materials consisting of fine particles is inverse.

"Field methods for measuring size composition of bottom materials in salmon spawning beds are described, and an empirical relationship between the fraction (by volume) of solids less than 0.833 mm. minimum dimension and coefficient of permeability of stream bottom materials

is given. Size of bottom materials in streams utilized for spawning by pink salmon (*Oncorhynchus gorbuscha*) varied considerably. The more productive spawning streams had the more permeable spawning beds. Adult pink salmon caused the removal of finer particles from bottom materials during spawning. The evidence indicates that the fine particles removed consist largely of organic matter. Logging caused fine sands and silts to accrue to spawning beds. Flooding caused the removal of fine particles from spawning beds."

(185) McNeil, William J., Philip Shapley, and Donald E. Bevan
1962. Effects of logging on pink salmon and spawning-bed improvement. *In* Ted S. Y. Koo [ed.], Research in Fisheries. Coll. Fish. Contrib. 139:15-18. Univ. Wash., Seattle.

A 6-year study on factors causing egg and larval mortality in three southeastern coastal salmon streams was conducted. The summary includes a discussion on the interrelationships among spawners, quality of intragravel water, quality of spawning bed, and the effect of these factors on egg and larval mortality. Spawning bed improvement studies on two of the salmon streams were also conducted.

(186) Neave, Ferris, and R. F. Foerster
1955. Problems of Pacific salmon management. Trans. North Am. Wildl. Conf. 20:426-439.

Past and present Pacific salmon management problems are discussed. The authors state that present research efforts are aimed toward increasing salmon production by decreasing freshwater mortality. Deforestation looms as the major problem of freshwater mortality.

(187) Neave, Ferris, and W. P. Wickett
1949. Factors affecting the freshwater development of Pacific salmon in British Columbia. 7th Pac. Sci. Congr. Proc. 4:548-556.

The ecology of the freshwater phases of Pacific salmon is discussed including the chemical, physical, and biological factors causing mortality in freshwater. The importance of freshwater factors as measured by adult populations is reviewed. The report also correlates adult populations with streamflow.

(188) Phillips, Robert W., and Homer J. Campbell
1962. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. Pac. Mar. Fish. Comm. Annu. Rep. 14:60-73.

The results of two studies designed to determine the effect of three environmental factors on embryonic survival of steelhead trout and

coho salmon are reported. The three environmental factors considered are: (1) dissolved oxygen concentration of the intragravel water, (2) seepage rate of intragravel water, and (3) permeability of the gravel. Also included in the report is a literature review of the effect of dissolved oxygen on embryonic survival.

(189) Phillips, Robert W., and K V. Koski
1969. A fry trap method for estimating salmonid survival from egg deposition to fry emergence. J. Fish Res. Board Can. 26:133-141.

"The method involves a trap of nylon netting placed over an individual redd with the trap's edges buried 15-20 cm in the gravel just outside the periphery of the redd. It has been used successfully on more than 70 coho salmon (*Oncorhynchus kisutch*) redds over the past 5 years, with as many as 2061 fry being captured from a single redd. The trap is relatively stable because it is flexible and conforms to the surface of the streambed, causing debris to float or roll over the surface. It can be used on individual redds; thus, emergent survival for separate parental combinations can be estimated. Field tests showed the efficiency of the trap approached 100%. Installation and presence of the trap had no significant effect on intragravel dissolved oxygen and gravel permeability. Mortality of fry in the traps averaged less than 1.5% when fry were removed at least three times a week. We concluded that the trap provides a more accurate estimate of survival from egg deposition through fry emergence than four other methods."

(190) Shapovalov, Leo, and Alan C. Taft
1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*), with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Fish & Game, Fish Bull. 98, 375 p.

The report describes the life history of the steelhead rainbow trout and the silver salmon. The authors discuss: (1) the correlation between number of eggs and size of fish, (2) the relationship between hatching time and temperature, (3) the effects of silting on the duration of survival, (4) factors influencing growth, timing and size of migration, and (5) the improvement of the biological and physical habitat.

(191) Sheridan, W. L., and S. T. Olson
1970. Timber harvest and the salmon and trout fisheries of southeast Alaska. Presented to West. Div. Am. Fish. Soc., 10 p. Victoria, B.C., Can.

"The purpose of this paper is to (1) summarize the progress of timber harvest on National Forest lands in Alaska; (2) outline the status

of some of the fisheries that could be affected; (3) discuss past and present studies aimed at evaluating the effects of logging; (4) review progress of the opportunities for habitat improvement; and (5) point out the most pertinent problems needing attention."

(192) Sheridan, William L.
1962. Waterflow through a salmon spawning riffle in southeastern Alaska. U.S. Fish & Wildl. Serv. Spec. Sci. Rep., Fish. 407, 20 p.

"The following characteristics were studied in a small salmon stream in Southeastern Alaska from 1956 through 1959: (1) dissolved oxygen content of ground water, (2) variation of dissolved oxygen with depth in streambed, (3) temperature of ground water, (4) extent of ground-water seepage, (5) interchange of flowing stream water and water of streambed gravels, and (6) flow of water in the gravel of streambank and gravel bar.

"Ground water was generally low in dissolved oxygen content, and dissolved oxygen levels decreased with depth in streambed. Because of these and other points discussed in this paper, I conclude that the main source of intragravel water of high oxygen content is the flowing stream."

(193) Wells, Ralph A., and William J. McNeil
1970. Effect of quality of the spawning bed on growth and development of pink salmon embryos and alevins. U.S. Fish & Wildl. Serv. Spec. Sci. Rep., Fish. 616, 6 p.

"Among three segments of the spawning ground in Sashin Creek, southeastern Alaska, the largest and fastest developing embryos and alevins of pink salmon, *Oncorhynchus gorbuscha*, came from spawning gravels characterized by high levels of dissolved oxygen in intragravel water. The high oxygen levels occurred in a stream segment which has a relatively steep grade and coarse materials in the bed. No differences in water temperature were observed among the three segments."

(194) Wendler, Henry O., and Gene Deschamps
1955. Logging dams on coastal Washington streams. Wash. Dep. Fish., Fish. Res. Pap. 1(3):27-38.

The types and operations of log dams, their effects on fish life, early fisheries rehabilitation efforts, and rehabilitation efforts are discussed.

(195) Wickett, W. P.
1958. Review of certain environmental factors affecting the production of pink and chum salmon. J. Fish. Res. Board Can. 15(5):1103-1126.

"The relation between stock and numbers of spawners is obscured by annual environmental changes. Stream discharge at the time the spawners

are migrating upstream, at the time when the eggs are in the early stages of incubation, and extreme discharge during the period eggs and alevins are in the gravel can impose an eightfold variation in the stock resulting from a given number of spawners in one area. Ocean conditions soon after the fry enter the sea have been observed to increase or decrease survival by a factor of 3. The density of spawners that produces the greatest numbers of fry is related to the average permeability of the stream bottom. Preliminary data indicate that more spawners could be used to advantage in most areas of the coast."

(196) Wolf, P. H.
1950. American problems and practice, I. Salmon which disappeared. Salmon Trout Mag. 130:201-212.

The author states that among the many factors contributing to the elimination of salmon runs around Lake Ontario, siltings from erosion after extensive land cultivation and deforestation are the major contributors. Salmon fry disappear from silted areas of a river, whereas a good yield is found from less spoiled regions.

(197) Ziebell, Charles D.
1960. Problems associated with spawning and growth of salmonids in Northwest watersheds. *In* E. F. Eldridge [ed.], Proceedings of 7th symposium on water pollution research, p. 28-32. U.S. Dep. Health, Educ. & Welfare, Reg. IX, Portland, Oreg.

Our watershed problems fall into two basic categories, natural and manmade, which the author discusses with respect to spawning, incubation, and affiliated problems, as well as to fish growth problems emphasizing the need for more research and better control over logging operations.

MULTIPLE LOGGING EFFECTS

(198) Brode, John M., James W. Burns, and Gary E. Smith
1973. Effects of logging road construction on invertebrates in a small coastal stream. Calif. Fish & Game, Inland Fish. Adm. Rep. 73-1, 47 p.

"Benthos density, invertebrate drift rates, and salmonid diets were compared on two forks of Caspar Creek, Mendocino County, California, before and after the construction of a logging road on the South Fork. Road construction was immediately detrimental to most aquatic invertebrates in the South Fork, although conditions created favored Diptera and Plecoptera. The increases in these two insect orders offset losses of other invertebrates, causing the South Fork's benthos to increase about 122%, from 286.02 to 634.41 mg/m^2, immediately after the road construction. The impact of the road construction, however, was partially obscured by the fertilization of the South Fork's disturbed areas with 817 kg urea immediately after the road was completed. The urea probably enriched the stream's food base for insects. In addition, a comparable increase in benthos density occurred simultaneously in the undisturbed North Fork, indicating that the South Fork's immediate increase was not necessarily caused by the road construction and fertilization. Recolonization of the South Fork by other invertebrates was rapid and, within 2 years, the benthos was 1,347.54 mg/m^2, 371% greater than it had been prior to the road construction. The North Fork's benthos increased only 65% during the same period. Drift rates were highly variable in both streams, ranging from 0.43 to 3.57 mg/hr/net in the North Fork and from 1.07 to 3.89 in the South Fork. This variability was probably due to the low sampling effort and precluded any statistical comparisons of drift rates before and after the road construction. In both streams, Trichoptera and Coleoptera made up the greatest biomass of insect orders in the drift. Salmonid diets generally changed in response to changes in the availability of food items, with juvenile steelhead trout (*Salmo gairdneri*) and coho (silver) salmon (*Oncorhynchus kisutch*) consuming relatively more Diptera in the South Fork after the road construction."

(199) Burns, James W.
1972. Some effects of logging and associated road construction on northern California streams. Trans. Am. Fish. Soc. 101(1):1-17.

"The effects of logging and associated road construction on four California trout and salmon streams were investigated from 1966 through 1969. This study included measurements of streambed sedimentation, water quality, fish food abundance, and stream nursery capacity. Logging was found to be compatible with anadromous fish production when adequate attention was given to stream protection and channel clearance. The carrying capacities for juvenile salmonids of some stream sections were increased when high temperatures, low dissolved oxygen concentrations, and adverse sedimentation did not accompany the logging. Extensive use of bulldozers on steep slopes for road building and in stream channels during

debris removal caused excessive streambed sedimentation in narrow streams. Sustained logging prolonged adverse conditions in one stream and delayed stream recovery. Other aspects of logging on anadromous fish production on the Pacific Coast are discussed."

(200) Calhoun, Alex
1966. Bulldozer delinquents. Outdoor Calif. 27(8):10, 11, 19.

Watershed and stream damage in California and regulations needed to control logging damage are discussed.

(201) Calhoun, Alex
1967. Stream damage. *In* Man's effect on California watersheds, p. 363-380. Part III, 1965-1967. State Calif., Sacramento.

Stream damage on California watersheds by logging operations, dam construction, earth-moving activities, overgrazing, and placer mining is discussed. The main emphasis is concern with logging operations; and the author recommends that loggers should leave buffer strips, practice more effective erosion control on roads and skid trails, and stop using streambeds as working areas, roads, and skid trails.

(202) Calhoun, Alex, and Charles Seeley
1963. Logging damage to California streams in 1962. Calif. Fish & Game, Inland Fish. Admin. Rep. 63-2, 15 p.

"Careless logging operations continue to damage priceless watersheds and to degrade important salmon and trout streams in California. Destructive practices include use of streambeds as roadways, operation of heavy equipment in streams, tractor logging on steep slopes, and removal of streamside vegetation. Accelerated erosion compounds the damage. Valuable forest soils erode off the slopes and deposit in streams, smothering eggs, fish, and fish food. Organic logging debris may also pollute the streams.

"During 1962, 33 streams were damaged by logging operations, mostly in north coast counties. All are on private land.

"Careful timber harvesting on some private lands and in National Forests, has shown that such damage can be largely prevented.

"Model timber sales contracts requiring good practices to protect soils, streams, and timber would help inexperienced owners of timberlands to minimize damage by contract loggers.

"The increasingly serious problem of erosion control involves many agencies. It is beyond the power of the Department of Fish and Game

to solve alone. Nevertheless, we hope to hasten corrective action by calling attention to resulting stream damage. More research is needed to define this problem."

(203) Campbell, C. J.
1963. Fish management problems associated with timber harvesting. *In* Symposium--Forest watershed management, p. 331-337. Oreg. State Univ., Corvallis.

The article is a general discussion of fishery problems associated with timber management and harvesting.

(204) Chapman, D. W.
1963. Physical and biological effects of forest practices upon stream ecology. *In* Symposium--Forest watershed management, p. 321-330. Oreg. State Univ., Corvallis.

Changes induced by land treatments on the aquatic ecosystem and their effects on stream ecology are reviewed and discussed.

(205) DeWitt, John W.
1964. The fish and fish habitats of the coast redwood region in Mendocino, Humboldt, and Del Norte Counties in California. Final Rep., Coast Redwood Study. U.S. Natl. Park Serv., Proj. NPS-WASO-11-64-(4), 31 p. [Mimeogr.]

"The purpose of this report partly is to identify the common fishes and to describe their distributions, general abundance, and importance, and ecological status in the redwood forest region in Mendocino, Humboldt, and Del Norte Counties. It is also for the purpose of describing the general nature, extent, and condition of fish producing waters in this region.

"A discussion of the main fish and stream protection problems of the present and the future is presented. Special emphasis is given to the problem of protecting fish species peculiar to the redwood region and their habitats."

(206) Edgington, John R.
1969. The impact of logging on the ecology of two trout streams in north Idaho. 73 p. M.S. thesis, Univ. Idaho, Moscow.

"The effects of logging on two study locations, with a test and control stream, were studied for 11 years in northern Idaho. Clear and selective logging was carried out in varied percentages on the two locations. An impact on the stream ecology was noted early in the study due mainly to road construction. A decline then a gradual increase to previous levels was noted for four orders of stream insects with the exception of the order Plecoptera which showed a decline in abundance due

to siltation. There was no apparent effect on trout populations. The timing and methods of timber harvesting are credited for the moderate effects to the stream ecology."

(207) Ellis, Robert J., and William A. Smoker
1970. Report on a study of effects of log rafting and dumping on marine fauna in southeast Alaska, June 6-9, 1970. U.S. Fish & Wildl. Serv. Interdep. Rep., 11 p. Auke Bay Biol. Lab., Auke Bay, Alaska.

A reconnaissance survey was made of log dumping sites and their effects upon the marine fauna in the vicinity. The results showed a localized accumulation of bark and wood debris which eliminated plants and many animals in the immediate area.

(208) Fisk, Leonard, Eric Gerstung, Richard Hansen, and John Thomas
1966. Stream damage surveys--1966. Calif. Fish & Game, Inland Fish Adm. Rep. 66-10, 9 p.

"Four stream drainages were surveyed during July 1966 to determine the extent of damage from past logging and other activities. The streams are the Garcia River, Mendocino County; Redwood Creek, Humboldt County; North Fork of Battle Creek, Shasta County; and Middle Fork of Mokelumne River, Calaveras County.

"A total of 328 miles was surveyed. Of this, 108 miles (33%) were severely damaged, 27 miles (8%) more moderately damaged, 127.5 miles (39%) were lightly damaged, and 65.5 miles (20%) were undamaged.

"The most severe damage occurred in Redwood Creek and the Garcia River, both in the redwood forests of the Coast Range.

"In the North Fork of Battle Creek and in Forest Creek, tributary to the Middle Fork of Mokelumne River, there was five times the poundage of trout per unit area in undamaged control sections as in severely damaged areas.

"In Forest Creek, water temperatures increased about 0.5°F. per mile in well-shaded areas, compared to 1.5 to 2.0° F. per mile in unshaded areas."

(209) Froehlich, Henry A.
1971. Logging debris - managing a problem. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 112-117. Oreg. State Univ., Corvallis.

"Floatable debris in forested watersheds is produced by both natural and human action. The natural accumulation of organic debris and its subsequent flushing by periodic flood events are discussed. The frequency of major flood events since 1861 was examined and found to occur

at an average of only eight-year intervals. Flood damage studies show that one of the major contributors to storm damage is nonmanufactured debris. Studies were reviewed which show that logging debris adds significantly to the natural debris and often aggravates the flood damage. The impact of this debris movement on the forest road system was examined and a number of management techniques were discussed. A plan for reducing road and culvert damages is recommended."

(210) Fullerton, E. C.
1972. Fish, wildlife, and logging practices in the Sierra. Presented to Assem. Comm. Nat. Resour. & Conserv. 7 p. Sugar Pine Point State Park, Lake Tahoe, Nev.

This article presents a discussion of some of the effects which logging has on wildlife and its habitat in the Sierra. The discussion includes: (1) streamside vegetation, (2) logging debris disposal problems, (3) landslides, and (4) siltation and logging benefits to wildlife.

(211) Hall, James D., and Richard L. Lantz
1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. *In* T. G. Northcote [ed.], Proceedings of a symposium--Salmon and trout in streams, p. 355-375. Univ. B. C., Vancouver, B. C., Can.

"The effects of two patterns of Douglas-fir logging on water quality and fish populations have been studied in three coastal headwater streams. Clearcut logging of an entire watershed of 71 hectares (175 acres) is being compared to clearcutting in patches on a larger watershed of 304 hectares (750 acres), where about 30 percent of the area has been harvested and a strip of timber left along the stream. The third watershed of 203 hectares (500 acres) will remain unlogged as a control. Prelogging studies began in 1958, access roads were constructed in 1965, and logging took place in 1966.

"Substantial changes in temperature and dissolved oxygen content of stream water followed logging in the entirely clearcut watershed. A maximum temperature of 30°C and a maximum diurnal fluctuation of 16° were recorded. Comparable pre-logging maximums were 16° and 1.5°, respectively. Dissolved oxygen levels of surface and intragravel water dropped below 2 mg/l during logging operations. Survival of coho salmon and cutthroat trout in the clearcut watershed has been affected by logging, but the significance of the effect cannot yet be fully evaluated.

"No significant changes in the fish population or its habitat have been noted in the patch-cut watershed. Studies will continue for several years to evaluate long-term effects of logging on the stream and to determine the period of recovery."

(212) Hess, Lloyd J.
1969. The effects of logging road construction on insect drop into a small coastal stream. 58 p. M.S. thesis, Humboldt State Coll., Arcata, Calif.

"Because stream fisheries are so closely associated with forested watersheds, it is necessary that the streams and forests be managed jointly under a system of multiple use. This requires a knowledge of the interrelationships between these resources to yield maximum returns from both. It is the purpose of this paper to relate logging practices to fish management by ascertaining the effect of logging-road construction on the drop of insects into a stream.

"On the South Fork of Caspar Creek the insects falling into the stream were greatly increased after a logging road was built. A twofold increase in number and weight of insects occurred over the entire stream. In 'Disturbed' areas, where the road paralleled the stream, drop insects increased three and one half times by number and one and one half times by weight over the 'Insect-Control' area. In the 'Highly Disturbed' areas, where the road crossed the stream, insect numbers increased by five and one half times and a threefold increase by weight over the 'Insect-Control' area was noted.

"A more than proportionate amount of the increase occurred in those adult insects having aquatic immature stages. One such family, Chironomidae, had a greater occurrence after road construction than all insects combined before construction. This family showed the most significant change of the families studied."

(213) James, G. A.
1956. The physical effect of logging on salmon streams of southeast Alaska. USDA For. Serv. Stn. Pap. No. 5, 49 p. Alaska For. Res. Cent., Juneau, Alaska.

A 5-year study made on three streams concerning logging effects on streamflow, temperature, channel change, and sedimentation is summarized.

(214) James, G. A.
1957. The effect of logging on discharge, temperature and sedimentation of a salmon stream. USDA For. Serv. Tech. Note 39, 2 p. Alaska For. Res. Cent., Juneau, Alaska.

The effect of logging on streamflow, stream temperature, and sedimentation is analyzed. Increase in streamflow was found to be small; however, it occurred during the dry weather months and may prove to be beneficial to coho salmon fry and late migrating pink and chum fry. It may also help early spawning escapement upstream. Logging did not change stream temperature and sedimentation in the logged stream.

(215) Larkin, P. A., and graduate students
1959. The effects on fresh water fisheries of man-made activities in British Columbia. Can. Fish-Cult. 25:1-33.

"There can be no question that historically, extensive clear cut logging has had deleterious effects on populations of freshwater and anadromous fish, particularly in coastal areas. However, the recent trend to sustained yield management of forest resources together with the inclusion of practices in logging which are designed to protect fisheries resources, will no doubt greatly mitigate these effects in the future.

"At the same time, other trends in modern forestry practices are causing substantial concern to fisheries agencies. The indiscriminate spraying of large areas of forest for insect control is known to have disastrous effects on fish in streams. If forest spraying is to be carried on in the future on a large scale--and there are indications that it may be--fisheries agencies will require a greatly increased knowledge in this field upon which to base sound conservation measures."

(216) Lehman, Carl
1970. Effects of log storage on the Dungeness crab fishery in southeastern Alaska. Alaska Fish & Game. Comm. Fish. Res. & Dev. Act, Job Completion Rep., Proj. 5-10-R and 5-21-R, p. 39-43. Juneau, Alaska.

"The scanty observations made during this preliminary study have shown that the physical presence of bark and associated debris on the substrate mechanically reduces the suitability of the habitat for Dungeness crab. This mechanical effect is greatest in the immediate log-rafting area, and in the absence of strong current. When strong currents are present log-rafting debris is swept away and therefore has little effect upon the crab population in the immediate vicinity. What happens in the area where such debris is eventually deposited, or to the marine animals in such an area, is not within the scope of this study."

(217) Meehan, W. R., W. A. Farr, D. M. Bishop, and J. H. Patric
1969. Some effects of clearcutting on salmon habitat of two southeast Alaska streams. USDA For. Serv. Res. Pap. PNW-82, 45 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

The effects of clearcutting on streamflow, suspended sediment, stream temperature, log-debris jams, and indirectly on salmon populations of two watersheds were evaluated and compared with an uncut watershed in southeast Alaska. Although some effects were observed, the timber harvesting as practiced on these watersheds did not appear harmful to salmon habitat or populations.

(218) Narver, David W.
1971. Effects of logging debris on fish production. *In* James Morris [ed.], Proceedings of a Symposium--Forest land uses and stream environment, p. 100-111. Oreg. State Univ., Corvallis.

"Stream salmonids (8 species of Pacific salmon, trout, and char) are discussed in relation to their environmental requirements and the possible impact of logging debris on their production. The emphasis is on small streams because of their great importance as nursery and spawning areas for certain species and because they may be more susceptible to damage than larger streams or rivers. Extensive use is made of pertinent literature. It is concluded that accumulations of logging debris in small streams can have serious consequences on the production of salmonid fishes."

(219) Narver, David W.
1972. A survey of some possible effects of logging on two eastern Vancouver Island streams. Fish. Res. Board Can., Tech. Rep. 323, 55 p.

"The lack of British Columbia studies relating logging practices to salmon and trout production was the basic reason for a 1970 survey of sections of two streams on the east coast of Vancouver Island. The objective was to compare fish populations, invertebrate drift, stream temperatures and stream channel widths in recently clearcut and burned stream sections and adjacent upstream sections in standing timber.

"Late summer standing stock estimates of the trout population in Jump Creek was considerably greater in the timbered (2226 fish/acre and 38.8 lbs/acre) than the logged section (1420 fish/acre and 3.9 lbs/acre). The standing stock of juvenile coho salmon and steelhead in Wolf Creek ranged from 6722 fish/acre (27.9 lbs/acre) to 10,206 fish/acre (49.8 lbs/acre) with the highest density (mainly steelhead) in the logged sections. Stock estimates for these two streams are similar or higher in comparison to other stream salmonid populations reported in the literature.

"Other possible effects of logging revealed in this survey was fish size, stream temperature and stream channel width. A larger average size of each age group of trout in the logged section of Jump Creek compared to the timbered section may have been related to higher stream temperatures in June and July leading to faster development of pre-emergent fry and earlier emergence. Stream temperature in the logged sections were higher than in upstream timbered sections. In Jump Creek maximum temperature was 21.1° C (70.0° F) in the logged section and 15.1° C (59.2° F) in the timbered section; temperatures over 20° C (68° F) lasted only a few hours each day. The channel of both streams in the logged sections appeared badly eroded with cutbanks and wide gravel bars, but only in Wolf Creek was the channel significantly wider in the logged than the timbered sections."

(220) Reinhart, Kenneth G.
1972. Effects of clearcutting upon soil/water relations. *In* R. D. Nyland [ed.], A perspective on clearcutting in a changing world. Appl. For. Res. Inst. Misc. Rep. 4, p. 67-74. Syracuse, N.Y.

The effects of timber harvesting are discussed, including tree cutting and removal of products on (1) streamflow, (2) water yield, (3) storm flows, (4) sediment, (5) nutrients, and (6) aquatic plants and animals. The author states that the cornerstones of a good job from a soil and water standpoint are: "(1) restricting the size of clearcuts and scattering their location; and, (2) following the highest standards of road location, construction, and maintenance."

(221) Rich, Lowell R., H. G. Reynolds, and J. A. West
1961. The Workman Creek experimental watersheds. USDA For. Serv. Rocky Mt. For. & Range Exp. Stn., Stn. Pap. 65, 18 p. Fort Collins, Colo.

A study of the effects of logging on water quality and quantity is discussed.

It was also found that selective cutting in a central Arizona watershed did not greatly affect the rate of sedimentation in adjacent streams if made under carefully controlled conditions.

(222) Ringler, Neil Harrison
1969. Effects of logging on the spawning bed environment in two Oregon coastal streams. M.S. thesis, Oreg. State Univ., Corvallis.

"The effects of two patterns of logging on the intragravel environment were studied in three Oregon coastal streams between June 1968 and June 1969. The watershed of one stream (Needle Branch) had been clearcut, and that of a second stream (Deer Creek) cut in staggered settings in 1966. A third watershed (Flynn Creek) served as an unlogged control. The dissolved oxygen content, biochemical oxygen demand, and temperature of the intragravel water were determined, as well as the size composition and organic content of the gravel. Changes were evaluated in terms of their effects on the survival of salmonid eggs and alevins.

. . . . . .

"Dissolved oxygen in redds of Needle Branch averaged 7.15 mg/l, whereas that in Deer Creek averaged 8.91 mg/l during 1969. Oxygen levels in Needle Branch redds in 1969 were 37.4 percent lower than those reported in 1964. Oxygen in Deer Creek redds dropped 12.7 percent in the same period. Dissolved oxygen at permanent standpipe locations was significantly

lower than that in redds and showed greater variability. Oxygen levels were positively correlated with streamflow and negatively correlated with temperature.

"Organic content of the gravel ranged from 0.33 to 7.52 percent by weight: less than 3 percent of the organic material was larger than 6.35 mm. The quantity of organic material was directly related to the amount of fine sediment in the sample. Recent redds in Needle Branch contained significantly less organic debris than did former redds. However, the organic content of redds in Needle Branch did not differ statistically from that in Deer and Flynn Creeks. The biochemical oxygen demand of the intragravel water averaged 1.95 mg/l for the three streams; differences among streams were not statistically significant.

"Stratification of fine sediment was evident in many redds, but a definite pattern of stratification could not be detected. Gravel size composition in Needle Branch did not differ statistically from that of the other streams. Recent redds in Needle Branch contained significantly less sediment than did former redds.

"Intragravel water temperature lagged from 2 to 6 hours behind surface temperature in attaining the diurnal maximum. Water temperature decreased with depth in the gravel in Needle Branch and Deer Creek on clear days, but the intragravel water was almost isothermal in Flynn Creek. Fluctuation in intragravel water temperature occurred as early as March, and maxima as great as 19.7°C were recorded prior to complete emergence of coho salmon. Surface and intragravel temperatures reflected the amount of shade over the stream surface. Survival to emergence of coho salmon appeared to be little affected by the observed changes in the intragravel environment."

(223) Salo, Ernest O.
1967. Study of the effects of logging on pink salmon in Alaska. Soc. Am. For. Proc. 1966:59-62.

The effects of logging on the pink salmon of the Harris River and Twelvemile Creek are discussed. A temporary increase in fine sediments in the the salmon spawning gravels was found. The survival rate of eggs and fry decreased during the study period (1959-64), but the actual number of fry produced increased due to an increase in numbers of eggs deposited.

(224) Sheridan, W. L.
1949. Effects of deforestation and logging operations on watersheds with special reference to the effects on fish life in the streams. Fish. Res. Inst., Circ. 2, 15 p. Univ. Wash., Seattle.

"1. There is a direct relation of forest and streamflow according to most writers in the field. Denudation of timberland, depending on the extent to which it is carried on, may have the following effects on streams:

"a. Fluctuations in streamflow may be altered to such an extent that a deleterious effect on young fish and spawn would ensue.

"b. Temperatures of the water might be increased above the optimum level necessary for fish-life in the streams.

"c. The occurrence of erosion and silting may be so aggravated by removal of forest cover that an adverse effect on aquatic organisms and spawning beds would result.

"2. Accentuated runoff due to deforestation may scour stream bottoms, deposit sand bars and destroy aquatic organisms.

"3. Logging practices, depending on which methods of logging are used, may create a harmful environmental change for fish in the following manner:

"a. The unwise construction of dams might possibly block salmon migration and fishways would have to be built. Artificial regulation of this type may also prove detrimental to both spawning adults and eggs and young in the gravel.

"b. The use of streams as roadbeds down which logs would be dragged to tidewater could change the physical characteristics of the stream with a possible harmful effect on spawning fish, spawn, and also exert a diminishing effect on spawning areas.

"c. The accumulation of chips, sawdust, etc., in streams could create a biochemical oxygen demand possibly high enough to lower the dissolved oxygen level of the water to an extent that fish could not live.

"d. The construction of logging roads through forests might possibly increase erosion with a consequent heavier silting of the streams.

"5. The conclusions in any study of the influences of deforestation or logging in a new region due to the institution of pulp or paper mills in that region must be based on assumptions and data drawn from other areas in which similar work has been done."

(225) Sheridan, W. L., J. F. Weisgerber, and C. N. Wilson
1965. The effect of logging on twelve salmon streams in southeast Alaska. USDA For. Serv., 59 p. Alaska Reg., Juneau, Alaska. [Mimeogr.]

"The authors were accompanied at each of the streams by a representative of the local Forest Service office and, on eight streams, by

a member of the Alaska Department of Fish and Game. For each stream observations or measurements of the following items were recorded: (1) present vegetation in the cutting area; (2) evidence of any erosion; (3) stream characteristics, including configuration, gradient, particle size, evidence of bedload movement, pool-riffle relationship, water quality, approximate discharge and water stage, bank stability, and apparent spawning potential; (4) number of salmon in the stream; (5) log jams in the stream; and (6) overall changes since the 1950 examination. In addition, areas photographed in 1950 were relocated (where possible) and comparison photos taken."

(226) Stefanich, Frank
1956. The effects of logging on Pinkham Creek's fish population. Mont. Fish & Game. Fed. Aid in Fish Restoration, Job Completion Rep., Proj. F-7-R-6, 10 p.

"Eight randomly selected stations were sampled and a total of 401 eastern brook trout and 218 rainbow trout taken. The total weight and average condition factor C for the brook trout was 17.42 pounds and 36.1, respectively. For the rainbow trout, figures of 13.29 pounds and 25.3 were obtained for the total weight and average condition factor C. The total number of fish caught was higher than in 1955.

"Approximately 1,350 acres of timber were logged on Forest Service land, producing 13,587.26 MBM and 181,090 linear feet of poles. An estimated 1,000 MBM of timber was cut on private lands. To date, a total of 61,087 MBM of timber has been removed from the Pinkham Creek drainage."

(227) Stefanich, Frank
1957. The effects of logging on Pinkham Creek's fish population. Mont. Fish & Game. Fed. Aid in Fish Restoration, Job Completion Rep., Proj. F-7-R-6, 10 p.

"Eight randomly selected stations, each 300 feet long were sampled and 345 eastern brook trout and 226 rainbow trout were captured. The condition factor (C) of the eastern brook trout averaged 26.4 and the rainbow trout 32.2. Logging operations have continued and 1,180 acres of land were cut from a 5 to 95 percent cut. There was a slight increase of both total number and total weight of all trout captured."

(228) Stefanich, Frank A.
1955. The effects of logging on Pinkham Creek's fish population. Mont. State Dep. Fish & Game. Fed. Aid in Fish Restoration, Job Completion Rep., Proj. F-7-R-4, 5 p.

"Nine randomly selected sections, each 300 feet long were sampled and 388 eastern brook trout and 200 rainbow trout were captured.

The eastern brook trout comprised 66 percent of the population. The condition factor of the brook trout averaged 37.4 and the rainbow trout 38.9. Logging operations have continued and 1,250 acres have had some timber removed during the current year. Ninety percent of the logging was selective cut pine, fir and larch and the remainder was clear cut spruce. The rainbow trout were found to be more numerous in the lower sections than in the upper. There was a decrease in both numbers and weights of fish from that of the previous years. The rainbow trout suffered the greatest reduction. Some new erosion of the stream banks was observed in the portion of the stream in which the lower three stations are located."

(229) Steinbrenner, E. C.
1966. Logging on watersheds: what type, where, what disturbance? *In* Proceedings of a Symposium--Practical aspects of watershed management, p. 109-115. Oreg. State Univ., Corvallis.

"It appears that although we do have the scars on the landscape from past logging, once the problem was brought to light, improvements began to take shape. The development of new and better logging equipment has been encouraged and this equipment utilized to minimize disturbances to the watershed, thus maintaining the productivity of the forest lands.

"The forest industry moved into tree farming 25 years ago and is moving toward more intensive forestry. Among other things, the importance of maintaining the productivity of the land is recognized. Maintenance of improvement of site quality is a worthy objective in managing land for timber or water, or both."

(230) Wooldridge, David D.
1960. Watershed disturbance from tractor and skyline crane logging. J. For. 58(5):369-372.

"In a comparative study of logging methods, soil disturbance caused by a Wyssen Skyline Crane was only a quarter of that caused by a standard crawler tractor operation. Soil disturbance on the Skyline Crane area was found on fewer transects, less damage was evident in the residual stand, and less road construction was needed. These advantages suggest the possibility of using skyline logging systems for harvesting timber in municipal watersheds and other areas previously closed to logging because of erosive soil conditions or steep, broken terrain."

(231) Zach, L. W.
1951. Past logging affects little of watersheds. USDA For. Serv. Tech. Notes 8, p. 1. Alaska For. Res. Cent., Juneau, Alaska.

"Past logging near salmon streams in Southeast Alaska has disturbed the watersheds very little. A compilation of watershed areas compared to areas cut on 24 Forest Service timber sales adjoining streams showed the following:

"1. Southeast Alaska watersheds are small. On the 24 sales they ranged from 342 acres to 20,000 acres.

"2. Areas logged are small. They ranged from 18 acres to 178 acres.

"3. Average proportion of watershed cut over was only 1.3 percent. Individual sales ranged from 0.28 percent to 15.5 percent.

"4. Cutting is nearly always confined to the lower part of the watershed. In no case did cutting proceed more than two miles up a drainage.

"5. Southeast Alaska forest stands are so broken up and intermingled with nonmerchantable types that no great unbroken clear-cuttings or denuded watersheds can be expected."

STREAM PROTECTION

(232) Burwell, Dave
1971. Prevention of debris accumulation in streams by uphill felling. *In* James Morris [ed.], Proceedings of a symposium --Forest land uses and stream environment, p. 118-120. Oreg. State Univ., Corvallis.

"Felling trees uphill using a truck-mounted donkey and climber to attach the line, prevents breakage and distributes limbs and tops on slopes instead of in stream bottoms. Costs are two to three times those of comparable conventional cutting. Savings include the intangible of increased safety, lessened breakage, reduction of slash to eliminate burning and enable quicker regeneration, and reduction of expensive creek cleaning. These may more than offset additional costs."

(233) Evans, W. A., and F. B. Johnston
1973. Fish migration and fish passage--a practical guide to solving fish passage problems. USDA For. Serv., Reg. 5, 41 p.

"This report is prepared as a working guide for forest biologists and engineers who are confronted with the practical problems of providing fish passage through or over both natural and artificial structures in streams. Useful material has been selected from the various reference sources and combined to form a simplified source of information for the California Region."

(234) Federal Water Pollution Control Administration
1970. Industrial waste guide on logging practices. U.S. Dep. Inter., 40 p. Portland, Oreg.

Some of the problems involved in improper or poorly planned logging operations are described, and guidelines are prescribed which should be used to prevent such operations.

(235) Jones and Stokes Associates, Inc. and J. B. Gilbert Associates
1972. A study to develop administrative and regulatory practices to prevent water quality degradation resulting from logging and construction operations in the north coast of California. Prog. Rep., Stand. Agreement No. 1-5-018, 72 p. State Water Resour. Control Board, Sacramento, Calif.

This progress report is a summary of the studies conducted to date along with a prospectus of future work. The first of three sections contains a summary review of literature regarding the adverse effects of logging operations on water quality. The second section deals with a format for evaluating the potential impact of a proposed logging operation. The final section surveys the administrative and regulatory practices of other States, the Federal Government, and other State agencies in California.

(236) Lantz, Richard L.
1971. Guidelines for stream protection in logging operations. Oreg. State Game Comm., Rep. Res. Div., 29 p. Portland, Oreg.

Practical guidelines for the management of a coastal watershed in Oregon are presented. The aims of management are to maintain production of timber, fish, and high-quality water. By protecting streamside vegetation and minimizing sources of sedimentation, a watershed can be managed to benefit man. The report's main premise is that forestry and fishery management need not conflict but rather should work together for optimum success.

(237) Lawler, Thomas A.
1971. Resource protection possibilities and alternatives in logging. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 84-85. Oreg. State Univ., Corvallis.

"Forest land resources may be protected during logging through the use of many logging alternatives. Three forest management concepts are discussed relative to using various alternatives including equipment now available and available in the future. 1) Any extra costs incurred by using a logging method other than the most economical must be balanced by a benefit of at least equal value. 2) Forest lands should be inventoried to determine specific future logging standards or requirements which will be compatible with anticipated resource protection needs. This will give direction to equipment development and acquisition. 3) The public ultimately pays for and benefits from resource protection. Work must be done to determine how much protection the public is willing to pay for and how the costs should be borne."

(238) Oregon State Game Commission
1963. Precautions for stream and fish protection in road construction and logging operations. *In* Symposium--Forest watershed management, p. 338-340. Oreg. State Univ., Corvallis.

Recommended practices for fish and stream protection are listed. The report states that the most common causes of fish problems in forest lands are removal of bank cover, improperly laid culverts, siltation, and logging debris.

(239) Reid, Kenneth A.
1955. For better trout fishing. Pa. Angler 24(10):4, 5, 23.

In a study of trout production made in streams in the Adirondacks, more careful and well-planned logging practices are said to be needed to protect trout environments.

(240) Rothacher, Jack
1960. How much debris down the drainage? *In* Proceedings, Cooperative watershed management short course, p. 13-1 to 13-4. Oreg. State Coll., Corvallis.

The author points out problems associated with the question of where logging debris should be removed from streams. He suggests that if a stream is fed by a watershed larger than 40 acres, logs and chunks should be withheld from the stream or removed before the winter flows.

(241) Rothwell, R. L.
1971. Watershed management guidelines for logging and road construction. Can. For. Serv. Inform. Rep. A-X-42, 78 p. For. Res. Lab., Edmonton, Alberta, Can.

"This report presents a set of guidelines for logging and road construction to minimize erosion, sedimentation, and deterioration of water quality. In the absence of local research and information, the guidelines are based on an extensive literature survey of research results and practices in North America and on a broad reconnaissance of forest conditions in Alberta."

(242) Schneider, P. W.
1956. The effects of logging old-growth timber on fish management. Soc. Am. For. Proc. 1955:121-123.

Effects of logging virgin timber and the best way to avoid excessive damage to fishery resources are discussed. Two approaches suggested are research on the responses of stream to various timber harvest practices and the integration of fishery considerations with timber harvest operations.

(243) Sheridan, William, Theodore Hoffman, and Sigurd Olson
1965. A technique for monitoring effects of land use on salmon streams in Alaska. 45th Annu. Conf. West. Assoc. Fish & Game Comm. Proc. 1965:155-159.

"Because of possible effects on salmon spawning environment in Alaska, a monitoring technique has been developed by the Forest Service in cooperation with the Alaska Department of Fish and Game. The general objective of the monitoring system is to detect changes in the spawning environment that adversely affect salmon production. Characteristics being monitored in one stream (soon to be followed by two others) are as follows:

"1. Composition of streambed spawning areas

"2. Streamflow and water temperature

"3. Stream channel configuration and amount and kind of debris in stream channel

"4. Soil types in the watershed

"5. Production of salmon fry

"6. Adult salmon escapement

"If changes in the salmon spawning environment, thought to be harmful, do occur, remedial measures can be undertaken. On the other hand, practices which may enhance the habitat can be expanded."

(244) Smedley, Stephen C.
1968. Progress report of joint stream monitoring by the Alaska Department of Fish and Game and U.S. Forest Service. *In* Richard T. Myren [ed.], Logging and salmon, p. 48-61. Proc. Forum Am. Inst. Fish. Res. Biol., Alaska Dist., Juneau, Alaska.

The monitoring system of three salmon streams in southeastern Alaska is discussed. The six characteristics monitored were: streambed gravel composition, yearly spawning escapement, preemergent pink salmon fry, streamflow, temperature, and incidence and movement of logs or debris in stream channels.

(245) Society of American Foresters, Columbia River Section, Water Management Committee
1959. Recommended logging practices for watershed protection in western Oregon. J. For. 57(6):460-465.

Recommended practices for watershed protection are outlined in the order in which problems occur in logging operations.

(246) Society of American Foresters, Columbia River Section, Water Management Committee
1961. Watershed protection. A manual for forest landowners. Oreg. State Coll., 16 p. Corvallis, Oreg.; Coll. Press.

The manual serves as a nontechnical guide for logging and multiple-use management by private landowners and the general public. The report states that to provide shade and protection from erosion the streambank should be protected from the wind whenever possible.

(247) USDA Forest Service, Alaska Department of Fish and Game, and Alaska Department of Natural Resources
[n.d.] Logging and fish habitat. 22 p. Juneau, Alaska.

"This pamphlet, directed mainly to timber sale administrators and loggers, describes some of the major habitat requirements of trout and salmon and lists some basic practices that will help to protect the habitat."

(248) Wilson, Robert L.
1960. Reducing erosion in the construction of logging roads. *In* Proceedings, Cooperative watershed management short course, p. 17-1 to 17-4. Oreg. State Coll., Corvallis.

"Erosion on logging roads can be minimized by increasing the angle to the back slope, hence reducing the area of slope subject to erosion, and by proper construction methods such as keying in all fill material and by compacting the subgrade."

STREAM IMPROVEMENT

(249) Bishop, Daniel M., and S. Philip Shapley
1963. Effects of log-debris jams on southeast Alaska salmon streams. [Abstract.] 13th Alaskan Sci. Conf. Proc. 1962:90.

"Log debris jams which were constructed on Maybeso Creek, Prince of Wales Island, induced streambed scouring under and around the jams and downstream migration and deposition of bedload. Fall floods which washed out the jams, removed fine material in the gravel which was accompanied by significant increase in dissolved oxygen in one of the jam areas.

"Log jams created unstable streambeds by maintaining readily changeable conditions and concentrating high flows in the vicinity of the construction.

"Salmon eggs deposited near the log jams may be washed out or buried thus gravel movement above a certain degree may offset the advantages of improved quality of inter-gravel water."

(250) Boussu, Marvin F.
1954. Relationship between trout populations and cover on a small stream. J. Wildl. Manage. 18(2):229-239.

"The study showed that trout populations in Trout Creek, Gallatin County, Montana, can be directly correlated with natural cover, application of artificial cover, and removal of natural cover on the stream."

(251) Broad, Robert D., and Harold A. Gangmark
1956. Establishment of a controlled flow area and construction of king salmon spawning pens at Mill Creek, California. Prog. Fish-Cult. 18(3):131-134.

"An isolated channel that leads independently from Mill Creek to the Sacramento River was selected for conducting experimental spawning and incubation studies. Spawning pens and a water-control dam were built as essential counterparts of the experimental area. Brush, silt, sand, and gravel were bulldozed from its entrance to reestablish flow into the channel. A length of corrugated metal pipe was laid in the channel and covered with earth to create a dam extending 8 feet above the pipe. A headgate (Calco Model 101) was mounted at the upstream end of the pipe for flow regulation.

"Stream improvement work was done in the old channel for approximately 1,000 feet below the dam. This involved removing large rocks, loosening gravel, and freeing it of silt and sand. The channel was made a uniform width, and the slopes of each riffle were made constant. Two additional settling ponds were excavated below the dam."

(252) Helmers, A. E.
1966. Some effects of log jams and flooding in a salmon spawning stream. USDA For. Serv. Res. Note NOR-14, 4 p. North. For. Exp. Stn., Juneau, Alaska.

"Streambed scouring and deposition occurred in the areas of two constructed log-debris jams. Gravel shifting associated with jams and flood flows reduced the fine material content of the streambed gravel and may have been responsible for the increased dissolved oxygen concentration.

"Log-debris jams intensify streambed instability, especially during floods. They may reduce salmon production in otherwise favorable areas. Gravel movement presumably reduces egg and larvae survival. On the other hand, loss of fine material because of gravel movement should benefit the salmon development environment by improving intragravel waterflow, thus increasing dissolved oxygen availability and making possible more effective removal of metabolic wastes. The effect of log-debris jams on salmon production remains undetermined. From a conservative viewpoint, however, temporary or unstable jams are judged to be detrimental."

(253) Holman, Gerald, and Willis A. Evans
1964. Stream clearance project-completion report Noyo River, Mendocino County. Calif. Fish & Game, Inland Fish. Adm. Rep. 64-10, 13 p.

"This report covers one of the first major stream clearance projects to be conducted in the State. Activities are described from the initial surveys to post project inspections.

"A total of 36 miles of spawning and nursery areas of the Noyo River drainage were improved at a cost of slightly over $19,000. Clearance work was conducted by use of Conservation Camp personnel.

"The project was deemed beneficial, although no satisfactory method was devised to evaluate results. Contrary to popular belief, the principal benefit of log jam removal is not removal of impassable barriers. It is improvement of habitat by permitting scouring winter flows to remove silt and gravel deposited behind log jams. It is believed that both spawning conditions and food production are thus removed for anadromous fishes."

(254) Meehan, William R.
1971. Effects of gravel cleaning on bottom organisms in three southeast Alaska streams. Prog. Fish-Cult. 33(2):107-111.

"The cleaning of gravel in three streams by the gravel shifter initially reduced the bottom fauna populations in each of these streams,

but within 1 year these populations apparently returned to the pretreatment levels in each of the streams."

(255) Merrell, T. R.
1951. Stream improvement as conducted in Oregon on the Clatskanie River and tributaries. Fish. Comm. Oreg., Res. Briefs 3:41-47.

"All evidence seems to point to the fact that drastic clearance of logs and debris from salmon streams increases accessibility and at least does not damage productivity. Although the stream bottom was greatly disturbed, in less than a year natural conditions had largely restored themselves. About 15 additional miles of stream were made readily available to spawning salmonoids.

"It is believed that due to improvements made the Clatskanie and its tributaries are at present capable of providing spawning and rearing facilities for large numbers of silver salmon and steelhead trout."

(256) Nobel, E. L., and L. J. Lundeen
1971. Analysis of rehabilitation treatment alternatives for sediment control. *In* James Morris [ed.], Proceedings of a symposium--Forest land uses and stream environment, p. 86-96. Oreg. State Univ., Corvallis.

"The aquatic environment of the South Fork Salmon River has been severely damaged in recent years by excessive rates of sediment production. A special study was conducted to determine the source and extent of the damage, and measures required to reduce future sediment production to a 'tolerable' level. Linear programming was used as an aid to select from 190 possible treatment alternatives and minimize treatment costs at various levels of sediment reduction. The desired level of sediment could be reached at a cost of $5 million. Debris basins to trap sediment moving in the channel proved to be the most effective and economical type of treatment while control of sediment production from roads and timber harvest on steep, fragile lands would have a very high cost."

(257) Richard, James A.
1963. Log stream improvement devices and their effects upon the fish population, south fork Mokelumne River, Calaveras County. Calif. Fish & Game, Inland Fish. Admin. Rep. 63-7, 12 p.

Richard states that due to severe bank erosion at the ends of the dams the construction of log dams proved ineffective for increasing fish populations or improving trout stream habitat. Log stream improvement devices are recommended only for controlled streamflows.

(258) Sheridan, W. L.
1969. Benefit/cost aspects of salmon habitat improvement in the Alaska Region. USDA For. Serv., 47 p. Branch Wildl. Manage., Reg. 10, Juneau, Alaska.

"...the purpose of this report is to:

"1. Present a method of benefit/cost analysis of habitat improvement projects whereby funds can be allotted to obtain the highest dollar return on the investment.

"2. Using a completed project, demonstrate how the method works in terms of project costs, benefits actually realized to date, and future returns.

"3. Present benefit/cost analyses for a series of proposed representative fish habitat improvements projects not yet funded."

(259) Sheridan, W. L.
1969. Effects of log debris jams on salmon spawning riffles in Saginaw Creek.... USDA For. Serv., 12 p. Juneau, Alaska.

"A preliminary study of the effect of log debris jams on salmon spawning habitat was made in Saginaw Creek on Kuiu Island in June, 1968. This study showed that about 27 percent of the area in one lineal mile of this stream had been eliminated as spawning area by log jams. Recommendations are made for judicial removal of jams and leaning trees, especially while a logging operator is in the watershed. Discounted benefit cost ratio is 34:1 for removal of a log jam and 342:1 for removal of leaning trees."

(260) Sheridan, W. L., Richard W. Wilke, and S. T. Olson
1968. The gravel cleaner ("Riffle Sifter"). USDA For. Serv. Prog. Rep., 1967, 8 p. Alaska Reg., Juneau, Alaska.

"Research in fisheries and engineering has shown that egg to fry survival of salmon embryos is higher in sediment free gravels. For this reason, the Forest Service is developing equipment to remove sediment from spawning gravels. A prototype model was developed by Forest Service engineers in 1964, and a working model was developed by the Clark Equipment Company in 1966. The equipment was tested in Alaska in 1966 and 1967. Although mechanical failures precluded thorough testing in Alaska, it was demonstrated that the equipment would remove large quantities of sediment from streambed gravels and that the principle of jetting the fines to the surface where they can be sucked up and disposed of is sound. The history of development and the results of testing of the "Riffle Sifter" are given in this progress report. It is not anticipated that a production (working) model will be available for use in Alaska prior to 1969."

MULTIPLE-USE MANAGEMENT

(261) Andersen, Harold E., and George A. James
1957. Watershed management and research on salmon streams of southeast Alaska. J. For. 55(1):14-17.

General problems associated with logging on salmon streams are discussed; i.e., sedimentation, temperature increases, and log jams. Restrictions in timber sale contracts are also reviewed.

(262) Borovicka, Robert L.
1968. Consideration of aquatic resources with forest practices in western Oregon. Presented to Oreg. State For. Dep., For.-Fish. Habitat Semin., 9 p. Tillamook, Oreg.

The Multiple-Use Act is discussed; defining its multiple uses to fisheries and forestry. The importance of the fishery resource affected by forestry practices in Oregon is pointed out, as well as forest practices which have helped fisheries.

(263) Bullard, W. E.
1950. Some references on watershed management. USDA For. Serv. Pac. Northwest For. & Range Exp. Stn., Res. Note 63, 26 p. Portland, Oreg.

The relationship of forest vegetation to climate, soil, erosion, runoff, and streamflow and the effects of logging on each are summarized.

(264) Bureau of Land Management
1970. An allowable cut plan for western Oregon. 90 p. U.S. Dep. Inter., Portland, Oreg.

"The purpose of this report is to present the results of the application of the BLM proposed allowable cut policies and procedures to the recent re-inventory of BLM's western Oregon forest lands. It identifies the highest level of sustained timber production that can be economically achieved under environmentally sound management. A further objective is to develop a program indicating the manpower, funding and the size and timing of investments needed to implement timber production, multiple use, and environmental protection."

(265) Cosens, Richard D.
1958. Reducing logging damage. USDA For. Serv. Calif. For. & Range Exp. Stn. Res. Note 82, 9 p. Berkeley.

Preventing logging damage will be made easier by

"1. Preparing and carrying out a detailed logging plan aimed at reduction of damage.

"2. Properly training and supervising logging crews; and

"3. Focusing engineering and logging ingenuity on designing equipment that will lessen damage to the advance growth as well as increase efficiency of yarding logs."

(266) Croft, A. R., and Marvin D. Hoover
1951. The relation of forests to our water supply. J. For. 49(4):245-249.

Several practices to reduce the deleterious effects of logging in the northern Rocky Mountains are suggested including selective cutting in a 200-400-ft strip along streams. The problem of erosion as related to water quality is briefly discussed.

(267) Gleason, Clark H.
1958. Watershed management--An annotated bibliography of erosion, streamflow, and water yield publications by the California Forest and Range Experiment Station. USDA For. Serv. Calif. For. & Range Exp. Stn. Tech. Pap. 23, 79 p. Berkeley.

"Bibliography has two purposes (1) to list and describe publications of the California Forest and Range Expt. Station and (2) to cite a few important early articles by other workers that helped set the stage for the station's work. Subjects covered include: (1) analytical methods, (2) climate, (3) floods and flood control, (4) geology, (5) instrumentation, (6) watershed management, (7) plant relations, (8) research programs and (9) soil relations and water relations."

(268) Greene, A. F. C.
1967. The relationship of aquatic wildlife habitats to forest management. Soc. Am. For. Proc. 1966:62-65.

Need for multiple-use management to protect and preserve our aquatic wildlife habitat is discussed.

(269) Hagenstein, W. D .
1953. The tree farm program--an asset to fish and game management. J. For. 51(9):620-623.

Hagenstein states that the controlled logging programs in Douglas-fir forests benefit the hunter and fisherman because ground cover is seldom lacking more than 6 months during the year due to natural plant selection. Water courses can be protected through the use of streamside strips and forest rotation.

(270) Neale, Alfred T.
1953. Watershed problems and their relation to water quality. Wash. Pollut. Control Comm., Tech. Bull. 15, 16 p. Olympia.

Several methods of operations are suggested for use in commercial and recreational activities in forested watersheds with streams which support anadromous fish runs. Author suggests leaving a buffer strip at least 30 feet wide, except "in special cases where stream banks are subject to undercutting."

(271) Needham, Paul R., and Fred W. Johnson
1949. Forests and fish. *In* A. Stefferud [ed.], Trees, the yearbook of agriculture, p. 581-585. Washington, D.C.: U.S. Gov. Print. Off.

Importance of multiple-use management in relation to factors affecting fish populations is discussed.

(272) Packer, Paul E.
1957. Management of forest watersheds and improvement of fish habitat. Trans. Am. Fish. Soc. 87:392-397.

"Management of forest watersheds in the western United States for protection against floods and sediment and to improve water yields can also be very beneficial in fishery management. Some of the important hydrologic processes that operate on watersheds are discussed. The principal kinds of watershed protection and water yield improvement problems are outlined and discussed in relation to maintenance of desirable fish habitat. Need for research to determine quantitative hydrologic relationships on watersheds and develop methods of forest management for better regulated and higher quality streamflow is emphasized."

(273) Schlapfer, T. A.
1972. Title 2100-multiple use management. USDA For. Serv., For. Serv. Man., Reg. 6, Suppl. 11, Code 2121.33, p. 27-34. Portland, Oreg.

The Manual:

"...Provides new policy and guidelines for protecting water quality through establishment of 'streamside management units' (SMU). Stream classification is determined by use made of water and each class has certain water quality objectives and criteria to be met in the conduct of land management activities."

(274) Smith, Allen C.
1963. Tractor roads and trails planning, use and post treatment. *In* Symposium--Forest watershed management, p. 283-289. Oreg. State Univ., Corvallis.

"In logging a watershed with tractors it should always be remembered that a tractor is very versatile; and weather, soil, slope, and other conditions should regulate plans and policies rather than pre-set rules. It should be possible to protect the watershed and still keep costs to a minimum so that a maximum return from the timber can be realized. Fire protection is of high importance because when fire destroys the timber the watershed may be ruined. Most areas are safer for fire control with skid trails distributed throughout.

"Protection of watershed areas should be easy with tractor logging if the logger realizes that this protection is part of his job."

(275) Tanner, Howard A.
1954. Place of game and fish in multiple use of watersheds. Trans. Am. Fish. Soc. 87:386-391.

"Fish and wildlife in the near future will often have to be fitted into multiple use programs for watersheds. This involves compromise between various desired uses of land and water; uses which may be compatible, conflicting or independent. If fish and wildlife are to receive proper consideration in the multiple use program, it is essential that there be more factual information on relationships of wildlife to habitat and on wildlife values. Public support must be won through the use of these facts."

(276) Toney, Robert D.
1961. Multiple-use management and its effect on logging practices. 11th Alaskan Sci. Conf. Proc. 1961:156-161.

"This paper has attempted to point out some of the ways in which other uses of the national forests affect timber harvesting and logging practices. There are, however, still areas where the only logging criteria are good forestry practices, but as the population increases and more and more people move into an area other uses for the land gain in importance and cannot be, and are not, ignored. Fisheries, water, and recreation are all gaining in importance, and it may be that someday the other uses for the national forests will become so important and widespread that standard logging practices will be obsolete."

(277) University of Washington
1971. Clear-cutting, impacts - options - trade-offs. Inst. For. Prod. Proc., Coll. For. Contemp. For. Ser. No. 1, 44 p. Seattle.

Discussions about the natural resources, including plants, soils, and water, the economics and politics of clearcutting, and land

use decisions are included. The conference was not designed to provide answers but to raise questions, to attempt to sort these questions as to their relevancy, and to provide information that might help those making policy decisions to arrive at useful answers.

(278) Willington, R. P.
1971. Forests, fish, and water. Symp. Cent. Contin. Educ. & Fac. For. 4 p. Univ. B. C., Vancouver, B.C., Can.

The purpose of the symposium was to identify some of the major problems in forest-fish-water resources, with the objective of reaching a consensus of opinion. Although conclusive unity of opinion was not achieved, some valuable generalizations were developed, including: (1) a need for more advanced planning in forestry operations, (2) operator supervision of operational plans, (3) research aimed at the operational level rather than at the academic or basic level, and (4) retraining or refresher education courses for all levels of research personnel.

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1960. Effect of land development on stream bottom faunas. N. Z. Ecol. Soc. Proc. 7:20-21.

(280) Barney, Charles W., and Robert E. Dils
1972. Bibliography of clearcutting in western forests. Coll. For. & Nat. Resour. 65 p. Colo. State Univ., Fort Collins.

(281) Bethlahmy, Nedavia
1960. Surface runoff and erosion--related problems of timber harvesting. J. Soil & Water Conserv. 15(4):158-161.

(282) Bureau of Land Management
1968. 6760-Stream preservation and improvement. U.S. Dep. Inter. BLM Man.

(283) Bureau of Land Management
1969. 5110-Stream protection. U.S. Dep. Inter. BLM Man. Suppl. Oreg. State Off., Portland.

(284) Bureau of Land Management
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(285) Chutter, F. M.
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(286) Copeland, Otis L., Jr.
1965. Land use and ecological factors in relation to sediment yields. U.S. Dep. Agric. Misc. Publ. 970:72-84.

(287) Dyrness, C. T.
1967. Grass-legume mixtures for roadside soil stabilization. USDA For. Serv. Res. Note PNW-71, 19 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

(288) Evans, Willis A.
1960. The effect of current west coast logging practices upon fisheries resources. Soc. Am. For. Proc. 1959:106-108.

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1957. Water quality depends on good forest management. Soc. Am. For. Proc. 1956:199-201.

(290) Gebhardt, Gary A.
1970. The influence of stream disturbance activity on aquatic organisms--a review. U.S. Dep. Inter. Bur. Land Manage., 43 p., Salem, Oreg.

(291) Hall, James D.
1968. Effects of logging on fish resources. Loggers Handb. 28(Sect. II):24-28.

(292) Hall, James D., and James T. Krygier
1967. Studies on effects of watershed practices on fish. Fed. Water Pollut. Control Admin. Res. Grant WP 423, Prog. Rep., 95 p. Oreg. State Univ., Corvallis.

(293) Hall, James D., and Thomas G. Scott
1969. Recreational and esthetic values of wildlife in relation to forest management. *In* Hugh C. Black [ed.], Proceedings of a Symposium, wildlife and reforestation in the Pacific Northwest, p. 22-25. Oreg. State Univ., Corvallis.

(294) Hansmann, Eugene W.
1973. Effects of logging on periphyton in coastal streams of Oregon. Ecology 54(1):194-199.

(295) Herbert, D. W. M., and J. C. Merkens
1961. The effect of suspended mineral solids on the survival of trout. Int. J. Air & Water Pollut. 5(1):46-55.

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1961. Increases in water yield after several types of forest cutting. Int. Assoc. Sci. Hydrol. Bull. 6:5-17.

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1970. Land management in municipal watersheds. J. Am. Water Works Assoc. 62:380-385.

(298) Juntunen, Erland T., and Logan A. Norris
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1959. Effects of siltation on production of fish food organisms. *In* E. F. Eldridge and John N. Wilson [eds.], Proceedings of 5th symposium--Pacific Northwest on siltation--its source and effects on aquatic environment, p. 13-15. U.S. Dep. Health, Educ. & Welfare, Portland, Oreg.

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1945. Relation of runoff and water quality to land and forest use in the Green River watershed. J. Am. Water Works Assoc. 37:21-31.

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1948. The effect of uncontrolled logging on stream turbidity. Water Sewage Works 95(7):255-258.

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1972. Accelerated mass wasting after logging and slash burning in western Oregon. J. Soil & Water Conserv. 27(3): 112-114.

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1970. Fish versus culverts. USDA For. Serv. Eng. Tech. Rep. ETR-7700-5, 19 p. Washington, D.C.

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1969. Forests and floods: a reconsideration. Presented to Watershed Manage. Sect., Soc. Am. For., 6 p.

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1966. Forest influences on streamflow hydrology. *In* Proceedings of a symposium--Practical aspects of watershed management, p. 28-37. Oreg. State Univ., Corvallis

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1967. Hydrologic and related characteristics of three small watersheds in the Oregon Cascades. USDA For. Serv., 54 p. Pac. Northwest For. & Range Exp. Stn., Portland, Oreg.

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SUBJECT INDEX[1]

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[1]Italics identify entries for which index subject is the major interest.

AUTHOR INDEX

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The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Development and evaluation of alternative methods and levels of resource management.
3. Achievement of optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research will be made available promptly. Project headquarters are at:

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The FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

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planning and processing multistage samples with a computer program--MUST

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Abstract

A computer program was written to handle multistage sampling designs in insect populations. It is, however, general enough to be used for any population where the number of stages does not exceed three. The program handles three types of sampling situations, all of which assume equal probability sampling. Option 1 takes estimates of sample variances, costs, and either a specified cost or precision and computes the optimum number of sampling units to select prior to sampling. Option 2 takes the observations, continuous or discrete, from a pilot survey or actual inventory and estimates the mean and variances. It then computes an estimate of the optimum number of units which should have been taken. Option 3 is a special case of the situation in option 2 where some of the observations are lost or for some other reason an unequal number of subunits per primary unit exists.

An explanation of multistage sampling and a processed example are included.

Keywords: Sampling design, computer program, forest entomology.

Introduction

The term multistage sampling refers to a method in which sampling units are sampled. The first stage of sampling occurs when a sample of primary sampling units is selected from the aggregate of such units making up the population. The second stage occurs when samples are selected from each of the primary sampling units from the first stage. Sometimes subsampling units are sampled creating a third stage composed of sub-subsampling units. This process can continue; however, it rarely goes beyond the fourth stage. This type of arrangement of sampling units is illustrated in a forest insect research study designed to estimate the average number of spruce budworm egg masses and the number of larvae per unit of foliage (Carolin 1972). The population was an acreage of infested Douglas-fir trees in eastern Oregon. The infestation occurred in small islands of trees in which Douglas-fir was the predominant tree species. Thus, the primary sampling unit was an area plot of which there were a large number (considered infinite) of such plots. Each plot was sampled by taking subplots systematically within the plot. A subplot involved a portion of an acre around the subplot center. A third stage of sampling occurred when trees were sampled within each subplot.

Studies such as this involving insects, range vegetation, and trees adapt themselves readily to multistage sampling. Multistage sampling can be applied when small elements of the population occur in clusters at one or more stages in the population, it is uneconomical to measure the variable of interest on all the subelements in a cluster, or a list of small elements is prohibitively difficult or expensive to construct.

The theory of multistage sampling is well established in texts (Cochran 1963, Sukhatme 1954, Yates 1949, and others); however, explanations of these techniques are not always easily understood by researchers nor are their applications always apparent. This is particularly the case in biological populations because the sampling units at each stage frequently may be defined in a variety of dimensions and arrangements.

Whenever multistage sampling is used, there is a problem in allocating effort to the various stages of sampling. In other words, what should the sample size be at each stage? One seeks that allocation of resources (i.e., time and money) which produces a given sampling error at least cost or, conversely, will produce the smallest sampling error for a given cost.

Implementing Multistage Sampling

This techniques report introduces a new computer program, MUST, which processes equal probability multistage samples and computes optimum sampling fractions at the various stages of sampling. It also presents to researchers the fundamentals of this particular class of sampling problems (i.e., multistage sampling problems), so that they will recognize them when confronted with such situations and be able to plan surveys and studies more efficiently.

One characteristic of biological populations which may exist and complicate the application of multistage sampling is the occurrence of units of unequal size. Drawing a sample from a collection of units of unequal size may be done on an equal or unequal probability basis. Unequal probability multistage sampling is not considered here (Cochran 1963, Langley 1969). Fortunately, most biological populations have large numbers of units at one

or more stages of sampling, so the size of samples at subsequent stages may be kept constant and the probability of selection assumed equal.

We mentioned previously that the shapes and dimensions of the units and subunits can frequently be changed by the researcher when they are not fixed by the way they occur in nature. Before one can estimate the optimum allocation of effort to the various stages, he must identify the stages of sampling and specify the sampling units (i.e., define specifically the size and shape of each unit from which observations are to be taken at each stage of sampling). Units which are small in size usually are distributed more evenly over an area than are large units (i.e., for an equal amount of the area sampled), but economic or practical reasons tend to favor larger units--measuring a larger area while on a plot and thus measuring fewer total plots cuts down on costs incurred by travel between plots. The decision of choosing the optimum-size sampling unit becomes one of choosing the alternative that minimizes the variance per unit of cost. This means that if two alternative sampling units are available one should choose the one which provides the smallest estimate of the variance given both samples cost the same. This problem in three-stage sampling is more complicated than this simple explanation because the definition of subsampling units are dependent upon the choice of sampling units at the first stage.

If the problem is extended to determining the optimum size and frequency of sampling units at each stage, then it becomes a mathematical programing problem. Further developments of this aspect of multistage sampling will not be considered in this paper.[1]

Assume that the researcher has identified his stages of sampling and decided upon the definitions of his sampling units by some suitable criteria so that he can progress toward determining the optimum number of units to be selected at each stage. The strategy for determining this optimum will be, as mentioned previously, to satisfy one of two possible objectives. The first is to choose the number of first-, second-, and third-stage units in the sample (n, m, and k) so the total cost of the survey is minimized, subject to achieving an expected level of precision (sampling error) on the estimate of interest. The second is to choose sample sizes to minimize the expected precision subject to achieving a specified cost of the survey.[2]

In three-stage sampling there are three variables (n, m, and k). It should be apparent that the precision can be increased or decreased by changing any one, two, or all three of these sample sizes.

[1] John W. Hazard and Lawrence C. Promnitz. Optimality in the design of successive forest surveys. (Submitted to For. Sci.)

[2] The discussion and illustrations from here on will be framed around three-stage sampling, since the program MUST will handle up to three stages.

To calculate an estimate of the optimum allocation of resources to the third and second stages of sampling (i.e., $\hat{k}_{opt}$ and $\hat{m}_{opt}$, respectively), one needs the following sample information:[3]

s_1^2 = the variance among first-stage unit means,

s_2^2 = the variance among second-stage unit means pooled over first-stage units,

s_3^2 = the variance among third-stage units pooled over the second- and first-stage units,

c_i, i = 1-3 are the respective costs per unit associated with taking units at each stage.

Note that these items of information are independent of the population sizes N, M, and K, and the specified precision or total cost. This means that k_{opt} and m_{opt} can be estimated from sample information. The number of sampling units at the first-stage, n, is a function of k_{opt} and m_{opt}, and it also depends upon which objective has been chosen. If the objective specifies a total cost, then an estimate of n results directly from substitution of the known items into the cost function. If, however, the objective involves a specified precision, then one needs to know N unless N is very large. In the latter case, n is a function only of the variance at the first stage.

Program Specifications

When an actual sampling problem arises, the researcher or sampler is faced with one of two situations. Either he must conduct a survey with no prior information about his population, or he is fortunate enough to have previous inventories or studies with some estimates of the variances and costs of sampling at each stage.

Perhaps the best approach, in the absence of prior knowledge of the population, is to consider running a pilot study to estimate the inputs to the allocation problem. If the required information (i.e., costs and variances) is present, then the techniques for determining n, m, and k are straightforward.

The program MUST processes three options:

Option 1. Predict optimum.--This option predicts the optimum n, m, and k when prior estimates (variances and costs) are available from a pilot study or other sources for input. The optimum is computed for minimizing cost or minimizing variance. Two sets of variance inputs may be used: Either estimates of the true variances, $(\hat{S}_i^2)$, are specified directly, or the sample variances, (s_i^2), are provided (Cochran 1963).

[3]Refer to the appendix for a complete explanation of the calculation of $\hat{k}_{opt}$, $\hat{m}_{opt}$, and $\hat{n}$.

Option 2. Equal subsamples.--This option accepts the individual observations from a pilot or an actual survey with either binomial or continuous random variables. It computes estimates of the population mean and variances, then computes the optimum for the cost or variance restriction from this sample for future surveys of this population or for evaluating the efficiency of this allocation.

Option 3. Unequal subsamples.--This option is used when the observations have been taken under the assumption of equal probability sampling and equal-sized units at each stage but, due to laboratory failures, etc., the samples end up unequal. Again, this option will process percentages or continuous variables, and it also computes the new optimum number of samples for future surveys.

Control Cards

Card 1

Title card

Columns	Format	Information
1- 5	A5	Punch TITLE.
6-75	7A10	Any ident. desired.
76-80	A5	If a Z appears in col. 80. the data will be listed.

As many TITLE cards may be used as desired.

Card 2

OPTION 1

Columns	Format	Information
1-15	A5, A10	Punch PREDICT OPTIMUM.
16-19		Blank.
20-24	F5.0	Size of the sampling universe for the first stage (N). If N = infinity, set to 99999.
25-28	F4.0	Size of the first-stage sample (n).
29-32	F4.0	Size of the sampling universe for the second-stage (M). If M = infinity, set to 9999.
33-36	F4.0	Size of the second-stage sample (m).
37-40	F4.0	Size of the sampling universe for the third-stage (K). If K = infinity, set to 9999.
41-44	F4.0	Size of the third-stage sample (k).

47-54	F8.I*	Cost of collecting a first-stage unit.
55-62	F8.I*	Cost of collecting a second-stage unit.
63-70	F8.I*	Cost of collecting a third-stage unit.
71-80	F10.I*	Total cost, if specified.

* If the number in the columns does not contain a decimal point, then the field is read with "I" being zero.

Card 3

OPTION 1. Predicting the optimum when the appropriate statistics are available from previous surveys.

Columns	Format	Information
1- 5	F5.I	Relative standard error, (percent/100).
6-15	F10.I	Absolute standard error.
16-25	F10.I	Estimated mean.
26-27	F2.0	Probability level.
28-34	F7.I	t-value.
35-45		Blank
46	A1	Leave blank if variances are unbiased estimates of the true population variance; otherwise, insert S, if variances are computed among means at the various stages (see reference).
47-54	F8.I	Estimated variance at first stage.
55-62	F8.I	Estimated variance at second stage.
63-70	F8.I	Estimated variance at third stage.
71-80	F10.I	$V(\bar{\bar{y}})$ specified. If the standard error and the t-value are specified, then $V(\bar{\bar{y}})$ will be calculated and this field ignored.

Card 2

OPTION 2. Predicting the optimum when the input must be summarized from a pilot or existing study.

Columns	Format	Information
1-19	5XII	Variable format where II is an integer count of the number of observations per card followed by the format for each observation (i.e., starting in col. 1 (5X10(F6.2)).
20-44		Same as card 2, option 1.
45		"1" if the observations are binomial data (i.e., yes or no). Only a summary of the number of yes observations needs to be entered. Blank, if data are continuous.
46		"1" if there are unequal sample sizes. Blank if equal sample sizes.
47-80		Same as card 2, option 1.

A card 3 will not occur with option 2 because the variances will be computed from the data.

Card 2

OPTION 3. Samples are selected under the assumption of equal-sized units (equal probability) but the size of samples ends up unequal due to losses of sampling units.

The card 2 format will be the same as for option 2, except column 46 must have a "1" punch.

Card 3

OPIION 3 (optional)

Columns	Format	Information
1- 5	A5	Punch "TWO" if unequal subsamples occur at second stage (left-justified).
6- 9	I3	A count of the number of second-stage samples within the first-stage unit.
10-12	I3	Second-stage unit.
13-80		In three-digit fields, identify the number of subunits sampled in the remaining primary units.

Card 4

OPTION 3 (optional)

Columns	Format	Information
1- 5	A5	Punch "THREE" if unequal subsamples occur at third stage.
6- 9	I3	Similar to card 3; identify the number of sub-subsampling units at the third stage within each second-stage sampling unit.
10-80		Repeat for all second-stage sampling units in three-digit fields.

Data Card

Columns	Format	Information
1- 5	A5	Punch DATA.
6-80	5X(II)	Data are punched in the format specified in card 2.

Data will be ordered $x(i, j, k)$ where k is within j and j within i. Between each job a STOP (cols. 1-4) card is required. The last card will be an end-of-data indicator (6,7,8,9 punched in col. 1). The order must also be consistent with the identification of sample sizes in cards 3 and 4.

Control card specifications, programed error messages, operating instructions, and examples of input data occur on comment cards at the beginning of the source program.

The program MUST is written for the CDC 6400; it will take up to 1,000 measurements over all stages (can be expanded easily), and it will process problems of up to three stages.

An Example of Field Use of MUST

A tussock moth egg survey for virus determination was run without knowledge of the relative variances at each stage. The situation was that a sample of 17 points was distributed over an area (assumed random). At each point, an average of approximately 23 egg masses were collected from a much larger number. Each egg mass had approximately 250 eggs from which an average of approximately 44 larvae were reared. The average number of eggs per egg mass varied from mass to mass but appeared to be constant enough to accept the average. This amounted to roughly 17,204 insects which were reared and examined for virus. The objective was to estimate the percent of insects which possessed this natural virus; thus, the observation $y_{ij\ell}$ is 1 or 0 depending on whether the insect does or does not have the virus. Under the option 2 alternative, the data were processed and the allocation computed. A summary of these data and estimates appears in table 1.

Looking at the lower part of the table, column 1 labels the particular stage of sampling, columns 2-7 present a summary of the statistics (i.e., the inputs to the optimization formulas), and column 8 the optima:

The population and sample sizes for each stage occur in columns 2 and 3.

The 99999 indicates an assumed infinite number of primary units (plots) of which 17 were selected at random.

The 9999 symbolizes an infinite number of egg masses per plot of which an unequal number (average of 22.47) was selected at random from the 17 plots.

There were an average of 250 eggs per egg mass of which an unequal number (approximately 44) was selected per egg mass from the 17 x 22.47 = 382 egg masses selected.

Sampling fractions are not presented for stages 1 and 2 in column 4 because they are infinite in size. The .17596 represents a weighted average sampling fraction for all 382 second-stage samples taken.

The values of s_1^2, s_2^2, and s_3^2 occur in column 5 labeled "SAMPLE VARIANCE," and unbiased estimates of the parameters S_1^2, S_2^2, and S_3^2 occur in column 6, "ESTIMATED POPN. VARIANCE." Either one may be used, but most frequently s_i^2's are available.

Costs in column 7 are assumed proportional to the frequency of sampling units. The cost function thus takes on the form:

$$c = c_i(n + nm + nmk).$$

TABLE 1.--MULTISTAGE ANALYSIS OF SAMPLE COUNTS AND COST DATA ON SAMPLING
P. MASON'S CALIFORNIA STUDY, VIRUS INSTARS 1 AND 2, OPTION 2

```
(5X31(F2.0))          99999  179999      250     11
TWO    24 24 24 22 17 25 22 17 23 25 24 24 25 24 30  6 26
THREE 45 45 29 48 46 46 48 50 13 34 40 47 42 47 43 43 31 19 46 48 49
THREE 43 45 49
THREE 50 72 46 41 48 41 48 43 47 46 18 50 45 43 31 49 50 40 43 68 40
THREE 49 42 21
THREE 50 42 34 20 27 50 34 49 58 19 47 25 58 64 50 50 49 50 24
THREE 38 49 43 35 49
THREE 41 50 47 35 41 48 49 32 47 44 11 84 43 50 13 33 24 45 50 38 47
THREE 43
THREE 31 39 50 50 09 48 37 40 38 49 50 49 29 49 50 27 03
THREE 50 64 50 42 79 50 43 50 50 49 48 22 44 54 82 49 50 46 45 07 49
THREE 47 50 50 49
THREE 49 44 07 05 50 11 17 50 28 17 08 25 29 45 03 35 12 46 50 33
THREE 14 11
THREE 49 48 47 49 14 45 50 47 44 56 47 38 20 87 47 46 05
THREE 49 46 50 50 46 49 50 19 50 50 50 50 49 50 49 48 43 55 43 49
THREE 50 50 50
THREE 39 50 49 50 50 48 50 49 26 47 50 49 50 50 50 50 50 47 50 50 47
THREE 47 27 50 49
THREE 50 27 41 50 46 50 50 34 42 50 50 47 50 50 50 44 48 35 50 59 50
THREE 49 50 48
THREE 50 30 50 24 50 50 48 18 23 11 76 46 50 48 50 49 05 36 50
THREE 49 07 37 12 12
THREE 47 50 47 47 93 50 01 49 47 50 48 48 45 69 63 29 50 49 37 49 50
THREE 50 54 49 36
THREE 49 47 50 50 48 50 49 50 46 50 46 50 47 33 49 50 50 48 38 49 44
THREE 32 49 50
THREE 49 50 50 50 46 34 50 50 48 50 50 49 50 50 49 48 43 46 50 44
THREE 47 56 27 50 46 49 50 50 48 49
THREE 49 49 45 49 50 48
THREE 27 49 50 50 50 50 47 48 50 48 50 50 50 50 50 45 50 50 60 50 47
THREE 49 50 49 50 48
DATA  031116050613060706050709032208171507160417211207
DATA  073003190208050314120414031104050516062326272600
DATA  150813061110072018042014112225261728090320072710
DATA  33022511072011041413003004230511100703161032
DATA  0410251405150422040925090616300703
DATA  30180413101432390725051306051333312923020814161124
DATA  05340203230303240911031713210115031523180201
DATA  3322101003303136433609111646201004
DATA  0903153315090202100510080917150107080912001208
DATA  01012611010001030102020402000403040305040603031706
DATA  03101030202040415070404070705060209020205001104
DATA  007104040602411127031107070600060118250100190403
DATA  010506311603201160706181103180307041503020911121203
DATA  0239060507030303030004270700001606060310613090607
DATA  2302042204051719020425302316030614180730351505361812060100620
DATA  144610071933
DATA  1606213121203407231512133621160318133531042835360506
```

	POPN. SIZE	SAMPLE SIZE	SAMPLING FRACTION	SAMPLE VARIANCE	ESTIMATED POPN. VARIANCE	COST	ESTIMATED OPTIMUM SAMPLE SIZE
STAGE 1	99999	17*		1.3549E-02	1.1835E-02		17.0
STAGE 2	9999	*		3.8525E-02	3.5610E-02		2.0
STAGE 3	250	*	.17596	1.5561E-01	1.5561E-01		2.0

	MULTISTAGE ESTIMATES
MEAN	2.915253E-01
VARIANCE	7.970234E-04

	SPECIFICATIONS FOR OPTIMUM
TOTAL COST	
STD. ERROR ABSOLUTE	
PERCENT/100	
PROB LEVEL	
T VALUE	

* UNEQUAL SAMPLES

BECAUSE THERE WERE NO COST LIMITS PER STAGE,THE COST OF EACH STAGE WAS CONSIDERED THE SAME

The cost values appear in the column labeled "COST" only if costs are entered; otherwise, they are assumed equal.

The optimum sample sizes for minimizing cost subject to meeting the computer variance, .00079702, are $\hat{k}_{opt}$ = 2.0; $\hat{m}_{opt}$ = 2.0; and $\hat{n}$ = 17.

The estimated average or proportion of insects possessing the virus appears under the heading "MULTISTAGE ESTIMATES." The value of this estimate is 29.1525E-02. This says that 29.15 percent were virus infected, and the variance of this estimated proportion is 7.970234E-04.

The striking thing about these results is that to satisfy the precision achieved of .00079702 would have required only 2 x 2 x 17 = 68 observations of larvae instead of the 17,204 actually taken. In other words, nothing is gained in the estimated precision of the mean virus occurrence of the population from measuring a large number of eggs per egg mass or a large number of egg masses per plot. It should be realized by now that a particular optimum solution is a characteristic of the population being sampled. If the intensity of infection or occurrence of virus-infected insects increases or decreases, the variances will change thus altering the optimum solution. One must therefore be particularly careful about borrowing input variances from other research studies or surveys. In other words, the variances one chooses for obtaining his optimum solution should be relatively bias-free estimates of his current population of interest.

Optimization problems of this type have a specific, well-defined objective. There are occasions when secondary objectives exist which are of a descriptive nature (e.g., descriptions of relationships of the larvae to their environment). When these occur, it may be desirable to take larger m and k to provide this other type of information, even though it may not be efficient from an estimation point of view.

Appendix

The optimum frequencies n, m, and k are functions of the true variances:

Variance among primary unit means

$$S_1^2 = \sum_{i=1}^{N} (\bar{Y}_{i\cdot} - \bar{\bar{Y}})^2/(N - 1)$$

Variance among second-stage unit means

$$S_2^2 = \sum_{i=1}^{N} \sum_{j=1}^{M} (\bar{Y}_{ij\cdot} - \bar{\bar{Y}}_{i\cdot})^2/N(M - 1)$$

Variance among third-stage unit means

$$S_3^2 = \sum_{i=1}^{N} \sum_{j=1}^{M} \sum_{\ell=1}^{K} (y_{ij\ell} - \bar{Y}_{ij\cdot})^2/NM(K - 1)$$

where:

$y_{ij\ell}$ is an observation of the ℓ^{th} third-stage unit within the j^{th} second-stage unit within the i^{th} first-stage unit,

$\bar{Y}_{ij\cdot}$ is the mean of the ℓ third-stage units within the j^{th} second stage and i^{th} first stage,

$\bar{\bar{Y}}_{i\cdot}$ is the mean over ℓ third-stage units and j second-stage units, within the i^{th} first-stage unit.

$\bar{\bar{\bar{Y}}}$ is the mean over all stages.

The appropriate sample-based estimates of these parameters are $\bar{y}_{ij\cdot}$, $\bar{\bar{y}}_{i\cdot}$, and $\bar{\bar{\bar{y}}}$. When random sampling is assumed at all stages, the sample mean $\bar{\bar{\bar{y}}}$ and $v(\bar{\bar{\bar{y}}})$ are unbiased estimators of $\bar{\bar{\bar{Y}}}$ and $V(\bar{\bar{\bar{y}}})$. The true variance and sample variance are:

$$V(\bar{\bar{\bar{y}}}) = (1 - f_1)\frac{S_1^2}{n} + (1 - f_2)\,\frac{S_2^2}{nm} + (1 - f_3)\,\frac{S_3^2}{nmk} \quad (1)$$

$$v(\bar{\bar{\bar{y}}}) = (1 - f_1)\frac{s_1^2}{n} + f_1(1 - f_2)\frac{s_2^2}{nm} + f_1 f_2(1 - f_3)\frac{s_3^2}{nmk} \quad (2)$$

where $f_1 = n/N$, $f_2 = m/M$, and $f_3 = k/K$ are the sampling fractions at the three stages, which means that N, M, and K must be the number of first-, second-, and third-stage units in the population.

If $k = K$, the problem reduces to a two-stage sampling problem. And logically, if $m = M$ and $k = K$, the problem is one-stage or simple random sampling.

Costs are a necessary consideration in computing estimates of the optimum number of elements at each stage. Let c_i be the average cost of taking an element at the i^{th} stage. Since each unit is composed of subunits, the cost associated with primary units must include all cost components associated with taking a primary unit, but not costs of measuring secondary units. The result is that if we omit travel costs between units and extraneous costs associated with each stage, then the total cost can be expressed as a linear function of n, m, and k; i.e.,

$$c(\text{total cost}) = c_1 n + c_2 nm + c_3 nmk.$$

Then, given these inputs, the optimum n, m, and k are (Cochran 1963):

$$k_{opt} = \left[\frac{S_3}{(S_2^2 - S_3^2/K)^{1/2}}\right]\left[\frac{c_2}{c_3}\right]^{1/2} \tag{3}$$

$$m_{opt} = \left[\frac{(S_2^2 - S_3^2/K)^{1/2}}{(S_1^2 - S_2^2/M)^{1/2}}\right]\left[\frac{c_1}{c_2}\right]^{1/2} \tag{4}$$

The size of n for a specified cost or specified precision are, respectively:

$$n = \frac{(c \text{ specified})}{(c_1 + c_2 m_{opt} + c_3 m_{opt} k_{opt})} \tag{5}$$

$$= \frac{S_1^2 + \dfrac{(1 - f_2)S_2^2}{m_{opt}} + \dfrac{(1 - f_3)S_3^2}{m_{opt} k_{opt}}}{(V(\bar{\bar{y}})\text{specified}) + S_1^2/N} \tag{6}$$

Since nothing is usually known about the S_i^2's or the values of N, M, and K, one can estimate n, m_{opt}, and k_{opt} by substituting estimates for the S_i^2's. Unbiased estimates of these true variances exist which are functions of the following sample variances (Sukhatme 1954--expression 56, page 310; 57, page 311):

$$s_1^2 = \sum_{i=1}^{n} (\bar{\bar{y}}_i - \bar{\bar{\bar{y}}})^2/(n - 1)$$

$$s_2^2 = \sum_{i=1}^{n} \sum_{j=1}^{m} (\bar{y}_{ij} - \bar{\bar{y}}_i)^2/n(m - 1)$$

$$s_3^2 = \sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{\ell=1}^{k} (y_{ij\ell} - \bar{y}_{ij})^2/nm(k - 1)$$

and

$$\hat{S}_1^2 = s_1^2 - (1 - f_2)\frac{s_2^2}{m} - (1 - f_3)\frac{s_3^2}{kM}$$

$$\hat{S}_2^2 = s_2^2 - (1 - f_3)\frac{s_3^2}{k}$$

$$\hat{S}_3^2 = s_3^2$$

Unbiased sample based estimators of equations (3) and (4) can be obtained by substituting the estimators $\hat{S}_i^2$, $i=1$, 2, or 3 into equations (3) and (4) and then simplifying. These estimators are:

$$\hat{k}_{opt} = \left[\frac{s_3}{(s_2^2 - s_3^2/k)^{1/2}}\right]\left[\frac{c_2}{c_3}\right]^{1/2} \tag{7}$$

$$\hat{m}_{opt} = \left[\frac{(s_2^2 - s_3^2/k)^{1/2}}{(s_1^2 - s_2^2/m)^{1/2}}\right]\left[\frac{c_1}{c_2}\right]^{1/2} \tag{8}$$

When $\hat{k}_{opt}$ and $\hat{m}_{opt}$ are computed, the values of k and m on the right-hand side of the estimators (7) and (8) come from the sample used to compute s_2^2 and s_3^2.

There are two estimators of n--choice depends upon whether the objective specifies a cost or variance restriction. The two forms are:

$$\hat{n}_{(\text{cost})} = \frac{(c \text{ specified})}{c_1 + c_2\hat{m}_{opt} + c_3\hat{m}_{opt}\hat{k}_{opt}} \tag{9}$$

$$\hat{n}_{(\text{variance})} = \frac{\hat{S}_1^{\,2} + \dfrac{(1-f_2)\hat{S}_2^{\,2}}{\hat{m}_{opt}} + \dfrac{(1-f_3)\hat{S}_3^{\,2}}{\hat{m}_{opt}\hat{k}_{opt}}}{(V(\bar{\bar{y}})\text{specified}) + \dfrac{\hat{S}_1^{\,2}}{N}} \tag{10}$$

Note that $\hat{k}_{opt}$, $\hat{m}_{opt}$, and $\hat{n}_{(\text{cost})}$ are functions of sample values. Nothing is required to be known about the population. Also, when M and K are large relative to $\hat{m}_{opt}$ and $\hat{k}_{opt}$, $\hat{n}_{(\text{variance})}$ simplifies to an expression in which only the population size N is required. It should also be apparent that, if N is very large (assumed infinite = 99999), the value of $\hat{n}_{(\text{variance})}$ approaches $s_1^{\,2}/V(\bar{\bar{y}})$ (specified) which is the case for simple random sampling from an infinite population. In equation (10), $\hat{n}_{(\text{variance})}$ is written as a function of $\hat{S}_i^{\,2}$'s instead of $s_i^{\,2}$'s. There is a reason for using (1) instead of (2) for arriving at equation (10). The estimators $\hat{S}_i^{\,2}$'s are unbiased estimators of $S_i^{\,2}$'s, and thus their expectations are always constants regardless of the size of n, m, and k. Whereas using (2) requires estimating $s_i^{\,2}$'s which are functions of the sample sizes m and k. In other words, if one increases the amount of sampling k, this affects the value of $s_2^{\,2}$ and $s_1^{\,2}$.

This point is not mentioned in Cochran (1963), but it is easy to show that (1) and (2) produce different values of n for the same set of sampling data.

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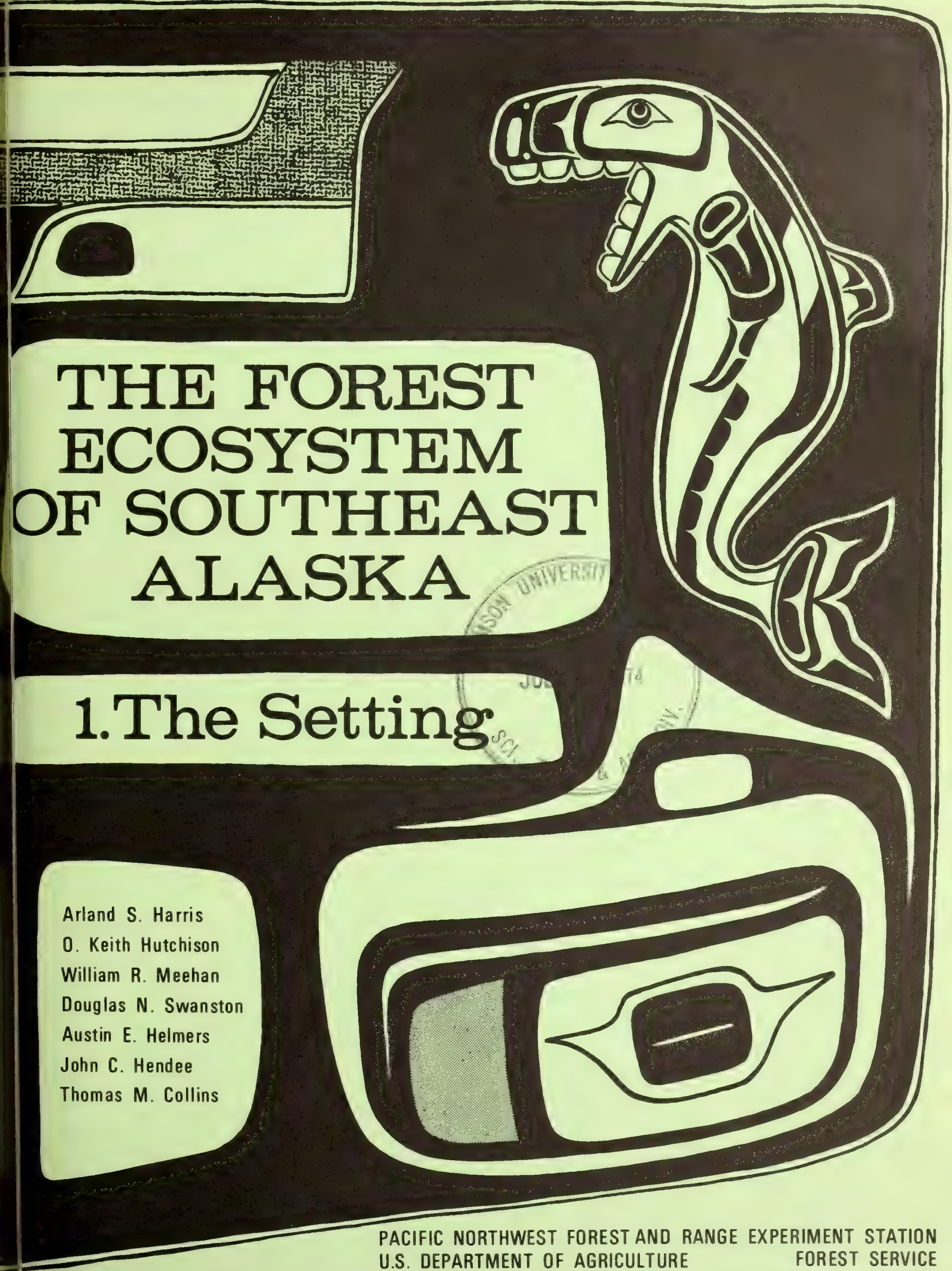

THE FOREST ECOSYSTEM OF SOUTHEAST ALASKA

1. The Setting

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ABSTRACT

A description of the discovery and exploration of southeast Alaska sets the scene for a discussion of the physical and biological features of this region. Subjects discussed include geography, climate, vegetation types, geology, minerals, forest products, soils, fish, wildlife, water, recreation, and esthetic values.

This is the first of a series of publications summarizing present knowledge of southeast Alaska's forest resources. Publications will follow which discuss in detail the subjects mentioned above and how this information can be helpful in managing the resources.

Keywords: Forest surveys, Alaska, resource planning, research.

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PREFACE

This, the first in a series of publications summarizing knowledge about the forest resources of southeast Alaska, describes the physical, biological, and socioeconomic setting of southeast Alaska. It provides a background for the more technical reports which will follow.

Our intent in presenting the information in these publications is to provide managers and users of southeast Alaska's forest resources with the most complete information available for estimating the consequences of various management alternatives.

In this series of papers, we will summarize published and unpublished reports and data as well as the observations of resource scientists and managers developed over years of experience in southeast Alaska. These compilations will be valuable in planning future research on forest management in southeast Alaska. The extensive lists of references will serve as a bibliography on forest resources and their utilization for this part of the United States.

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INTRODUCTION

In the changing fashions of organized study, science has passed through an era of emphasis on basic research. This emphasis has often left undone the interpretation of findings and their incorporation into the decisionmaking process. The reservoir of knowledge and technology accumulated through research is needed now more urgently than ever before to help solve natural resource management problems. The series of papers, of which this is the first, is an attempt to transfer technology from researchers to managers and users of southeastern Alaska ecosystems.

The objectives of this series of compilations are (1) to provide guidelines in managing the forest resources of southeast Alaska, (2) to establish a framework for multidisciplinary research, and (3) to bring together the pertinent published and unpublished information concerning the forest resources of southeast Alaska.

The geographic scope of this series is that portion of Alaska east of the 141st meridian (fig. 1). A problem analysis and "state-of-the-art" evaluation for the central and southwest coasts are also needed; however, research information for that area falls off sharply compared with southeast Alaska.

The scope of this group of papers includes:

Forest ecology	*Erosion and sedimentation*
Timber management	*Water*
Timber inventory	*Recreation and esthetics*
Fish and wildlife habitats	*Forest insects and diseases*

There are probably few places in the world where geologic and climatic variations are greater than in southeast Alaska. Around Juneau, for example, one can go from the salt-water depth of the Inland Passage to the perennial snow and ice of the Juneau Icefield in a horizontal distance of less than 8 miles and an elevational range of only 4,000 feet.

Physiography and climate combine to intensify glaciation, which is presently active; soils are young and poorly developed; many slopes are unstable; abundant rainfall and cool summers favor reforestation of logged-over areas; water in great quantity is important to fish resources. These features profoundly affect use and management of the land.

Industrial and economic developments are both old and new--fishing has a long history; large-scale timber harvesting is new; gold mining has come and, at least temporarily, is gone. There is a continuing small but steady interest in the extraction of minerals--some with large potential. The fur industry is essentially inactive. The social setting is new--Alaska is a new State, and a rapidly expanding population is responding to the opportunities to build and to benefit from newly tapped resources. It seems that "everyone wants to come to Alaska," at least to see the "great land," which means that the already important recreation and tourism activities will continue to expand.

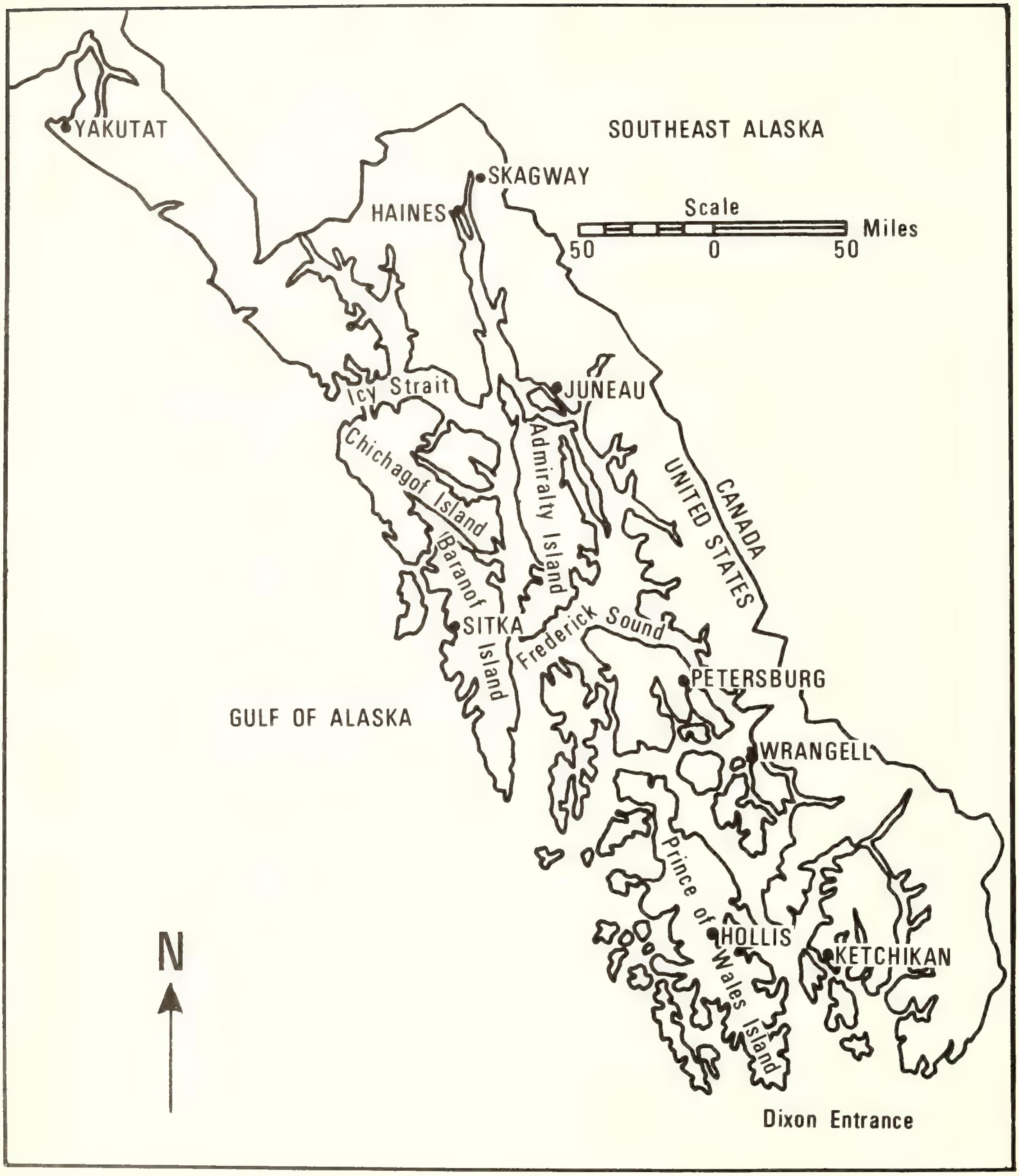

Figure 1.--Map of southeast Alaska east of the 141st meridian.

DISCOVERY AND HISTORY

The discovery of northwestern America by white men perhaps began when the Russians became curious about "the east." Shortly after Yermak Timofeief heard of "land to the east" from Anika Stroganoff in 1578 (Hartman et al. 1970), the Cossacks pushed across Siberia, until in 1639 Dimitrii Kopylov founded Okhotsk. The Chukotsk Peninsula was discovered in 1648. Mikhail Gvozdev was near, or landed on, Cape Prince of Wales, Seward Peninsula, in 1730 while exploring for the "great land" reported by the Chukchi natives (Alaska Chamber of Commerce 1938).

Southeast Alaska was first sighted during Captain-Commander Vitus Bering's second expedition of discovery. This expedition, which sailed for America from Petropavlovsk, Russia, on June 4, 1741, included two ships--the *St. Peter* with Bering and the scientist George Wilhelm Steller on board and the *St. Paul* under the command of Alexei Chirikov (Gruening 1954). After sailing eastward together for some days, the ships became separated and they proceeded independently.

On July 15, Chirikov sighted land near Cape Addington on Noyes Island off the west side of Prince of Wales Island. Lacking a suitable landing place he turned north and on July 19 entered a bay which is believed to be today's Sitka Harbor. Two boats were sent ashore--the first with 11 men and, several days later, a second boat with three men, which is presumably the first time that white man set foot in Alaska. Both boats failed to return; Chirikov returned to Petropavlovsk.

Bering searched for 3 days for the *St. Paul* after the ships became separated. He then sailed ENE and at about noon, July 16, sighted Mount St. Elias. Bering landed briefly on Kayak Island in Prince William Sound, where Steller went ashore to collect specimens and make observations. Bering subsequently made his way back as far as one of the Kommandorski Islands (Bering Island) during the first year of the expedition. There, he died, along with many of his crew.

A Spanish expedition, commanded by Juan Perez in the ship *Santiago*, sighted Prince of Wales Island on July 18, 1774. The next year, Lieutenant Juan Francisco de la Bodega y Quadra, with the schooner *Sonora*, sighted Mount Edgecumbe and, on the following day, anchored in Krestof Bay. He continued as far as 57°57' N. latitude before returning southward. Captain James Cook, on his third and last voyage of discovery in the Pacific, reached the Alaskan coast on May 1, 1778, named Mount Edgecumbe, Mount Fairweather, and Bering Bay (now Yakutat Bay). Quadra again visited southeast Alaska, arriving at Bucareli Bay on May 2, 1779. The French explorer La Perouse sighted Mount St. Elias on June 3, 1786, and entered Lituya Bay on July 3.

Captain George Dixon in the ship *Queen Charlotte*, and Captain Nathaniel Portlock in the *King George* visited southeast Alaska in 1787 in the service of the King George Sound Company. Captain Dixon sailed to Yakutat Bay, visited Sitka Sound, and then went to Dixon Entrance. Captain Portlock went to Chichagof Island where he entered and named Portlock Harbor.

In the wake of these early explorers and traders, so many Americans followed that "during the next 25 years...the Yankee skippers and their bucko mates were known in every bay and cove of the coast of southeastern Alaska." (Andrews 1931).

The last Spanish exploration was in 1792 when Lieutenant Jacinto Caamaño came to the Alexander Archipelago. He named Cape Chacon and other points but did not reach the mainland.

Captain George Vancouver explored much of southeast Alaska in 1793 and 1794. His surveys were finished at the harbor he named Port Conclusion. His departure from the southeast Alaska coast terminated the main era of exploration.

The Russian fur trade in Alaska began in 1743, but it was not until 1781 that it touched southeast Alaska. Fur exploration gradually expanded along the Aleutian Islands and the Alaska Peninsula until finally, as fur animals were depleted, the time and expense of seeking new grounds necessitated the formation of companies. In 1788 Eustrate Delaref sent the company navigator, Bocharof, on an exploratory voyage eastward on the ship *Three Saints*, which visited Yakutat Bay and Lituya Bay. At the time, Delaref was in charge of the Russian settlement on Kodiak Island, which had been established by the Shelekof-Golikof Company.

Alexander Baranof, who relieved Delaref as manager of the Shelekof-Golikof Company at Kodiak, extended sea otter hunting on a substantial scale to Yakutat and Cross Sound in 1794. In 1795, attempts to establish a colony at Yakutat miscarried, but Baranof visited Sitka to look for a possible post site. The Yakutat colony, called New Russia, was established in 1796, and in the spring of 1799 the Sitka site was occupied in what is now known as Starrigavan Bay.

The Sitka post was destroyed by the Tlingits in 1802; survivors returned to Kodiak. It was retaken in 1804 when the Tlingits were driven away and their fort destroyed. The regained outpost was named New Archangel.

In the ensuing years, the fur resources declined and competition from other countries increased. Leontii Hageimeister relieved Baranof as chief manager in January 1819, followed by M. Muravief, who assumed these duties in September 1820. Muravief allowed the Tlingits to return to Sitka in 1821.

The second charter of the Russian American Company was granted on September 13, 1821. The Russian government made treaties with the United States and with Great Britain, agreeing on provisions for coastal sailing, fishing, and trading with natives. These were regarded as an infringement of rights by the Russian American Company; the company continued to have difficulty with the natives of the Alexander Archipelago. After the U.S. trade agreement expired and was not renewed, intense competition developed between the Russian American Company and the Hudson's Bay Company, who had reached the Pacific coast and started trading in southeast Alaska. To prevent an English settlement on the Stikine River, Lieutenant Zarembo was sent in 1833 to the mouth of the river to establish a fort on

Wrangell Island at the present site of Wrangell. The failure of the Hudson's Bay Company attempt led to a 10-year lease to the Russian American Company of the coast from Portland Canal to Cape Spencer. Upon renewal, the coverage of the lease was extended to the time of transfer of the territory to the United States.

The fort at Wrangell was transferred to the Hudson's Bay Company in June 1840. In the same year, Fort Taku was built in Taku Harbor.

Under the third charter of the Russian American Company, which was dated October 10, 1844, the company discontinued the policy of trade expansion and acquisition of territory. Fur conservation begun by Baron Wrangell was continued. During the last of the Russian American Company period, the conservation of animals in the Seal Islands began to bear fruit and the company continued to prosper through sea otter hunting. Throughout this period the company employed Aleuts.

Support and trade activities in the Russian American colonies included the sale of ice to California. Another interesting product of southeastern Alaska could be obtained in Seattle and elsewhere by asking for "Zarembo Water"--bottled from a spring on Zarembo Island (Brown 1909). Sawmills were introduced at an early date. The machinery for one at Sitka was ordered by Rezanof in 1806. In 1848, a second mill was placed on Sawmill Creek at Silver Bay. Two flouring mills ground the grain brought from California and Chile. One mill was at Sitka and the other at Redoubt Lake near Sitka.

A tannery prepared leather from cattle hides from California and from sea lion skins from the coast. There was a well-equipped brass and iron foundry, with a machine shop.

Limestone, marble, graphite, coal, and gold were discovered. The waters off the Alaska coast became important whaling grounds by the early 1800's. Gold was discovered on the Stikine in 1861, and the little steamer *Flying Dutchman* ran as far upstream as Telegraph Creek. In southeast Alaska, the first gold discovery was made by Mix Sylvia at Windham Bay and Sumdum Bay in 1869. The first mining company was the Alaska Gold and Silver Mining Company at Silver Bay.

By mid-1850's during the Crimean War, the Emperor of Russia feared that England would seize Russian America. Also, by this time the Russians were suffering various encroachments in the colonies and were gradually losing their hold. The combined effect was an offer to sell the Russian America Colonies to the United States. The treaty of purchase was signed on March 30, 1867, and proclaimed by President Johnson on June 20. The formal transfer of Alaska to the United States took place at Sitka on October 18, 1867.

In the first half-century of United States rule, mining reached a peak with the gold production of southeast Alaska a substantial part of the total mineral values. Prospecting, discovery, and some development of other minerals also occurred. The fisheries were developing rapidly by the end of these first 50 years. Fur production, the main industry before U.S. rule, was continuing, and remained important partly due to the start of fur farming. The timber industry was small and producing for local use.

In the years that followed the first half-century, there were major shifts in resource use. From 1878 (when the first salmon cannery was erected) until the late 1950's fishing was the main prop of the regional economy (Rogers 1960), reaching a peak in 1941.

At present, mining is much reduced over previous production levels, especially since the closure of the Alaska Juneau, Treadwell, and Chichagof gold mining properties. Considerable prospecting and exploration continues with some small developments and production, in response to changing prices for various minerals. Price increases, such as for uranium, copper, and nickel, result in new flurries of prospecting and development.

In addition to trapping wild fur bearers, there was a period of fur farming in the 1920's and 1930's. However, generally unfavorable markets have reduced the fur trade to the low level of traditional winter activity for some of the indigenous population and to an incidental sport activity.

One of the major long-term values of Alaska is in recreational opportunities and associated wildlife and mountain scenery. Tourism, which started in the 1800's, is now developing rapidly with improved transportation means and routes.

Wood has become the basis for a major industry in southeastern Alaska. The big jump in annual cut was in 1954 when the first large pulpmill, Ketchikan Pulp Company (fig. 2), opened near Ketchikan.

Figure 2.--Ketchikan Pulp Company mill at Ward Cove, near Ketchikan, Alaska.

GEOGRAPHY

Southeastern Alaska is here defined as that part of the State lying east of the 141st meridian, consisting of the large group of islands known as the Alexander Archipelago and the narrow mainland strip between Dixon Entrance and Icy Bay. This area lies between latitudes about 54-1/2° and 60-1/2° North, extends east to the 130th meridian. It is about 120 miles in width and 525 miles in length in the northwesterly-southeasterly direction.

Southeastern Alaska is in about the same latitude as the northern part of the British Isles and the southern part of Norway and Sweden. Its latitudinal range is similar to the Kamchatka Peninsula of the U.S.S.R. and the west coast of the Sea of Okhotsk from Nikolayevsk to Okhotsk.

The Alexander Archipelago has hundreds of islands, of which 65 exceed 4 square miles in area, 15 exceed 100 square miles, and six exceed 1,000 square miles. These six large islands are: Prince of Wales (the largest, 2,770 square miles in area); Chichagof (2,062 square miles); Admiralty (1,709 square miles); Baranof (1,636 square miles); Revillagigedo (1,134 square miles); and Kupreanof (1,084 square miles).

The islands are separated by a system of seaways including sounds, straits, canals, narrows, and channels. There are nearly 10,000 miles of shoreline along the islands and mainland. For the most part the coastline is rocky and steep, but there are accessible beaches located within the numerous sheltered inlets, bays, arms, coves, harbors, and anchorages.

PHYSIOGRAPHY

The topography of southeast Alaska includes parts of two high mountain arcs (the Coast Mountains) and the intervening low mountains. These three features are part of the Pacific Mountain System. The eastern boundary range consists mainly of the mountains associated with the Coast Range Batholith. These are an extension of the Cascades in Washington and the Coast Mountains of British Columbia. Northwestward these mountains appear again in Alaska as the Nutzotin Mountains and the Alaska Range.

Major rivers in southeast Alaska originate in Canada, apparently as antecedent streams that maintained their courses as the coastal mountains rose. The principal rivers are the Alsek, Chilkat, Klehini, Taku, Whiting, and Stikine. Other important mainland rivers include the Salmon, Chickamin, Unuk, Bradfield, Speel, and Taiya Rivers.

Elevations along the boundary range peaks are 6,000 to 10,000 feet, with most of the main peaks between 7,000 and 9,000 feet. These elevations are of interest in terms of airmass lifting, precipitation, large number of glaciers, and several icefields. These mountains are the main factor in the spectacular scenery.

The seaward belt of mountains in southeastern Alaska is a discontinuous extension of the Vancouver system in British Columbia (Atwood 1940), manifest as the mountains of Baranof Island. Northwestward along the coast these mountains appear again as the Fairweather Range and the St. Elias group which connect to the westward with the Chugach Range.

Mount Fairweather rises to 15,300 feet; Mount St. Elias, the highest point (18,008 feet) in the southeast Alaska system, is the fourth highest peak in North America (Williams 1958). Areas of subdued relief are uncommon in southeast Alaska, but the most subdued is the belt of comparatively low islands that make up the Alexander Archipelago (U.S. Geological Survey 1958).

The northern part of southeast Alaska is rising as much as 2 to 4 centimeters (0.8 to 1.6 inches) per year (Hicks and Shofnos 1965), at least partly an isostatic rebound in response to the diminishing load of glaciers. Beach deposits are found above sea level at elevations ranging from a few feet on the southern end to many hundreds of feet in the Fairweather Range.

CLIMATE AND WEATHER

Southeast Alaska climate is maritime--cool and moist. The narrow temperature range is limited partly by the moderating influence of adjacent seas. The abundant moisture is derived from airmass lifting by the Coast Mountains (Fitton 1930). The overall effects are cool summers, moderate winters, considerable precipitation well distributed throughout the year, heavy snowfall at higher elevations resulting in large numbers of glaciers and several icefields, and a high incidence of cloudiness. All these climatic features have important effects on resource uses and management. For example: cool air temperatures and general cloudiness reduce the effect of timber harvesting on summer stream temperatures; moisture is not a limiting factor in tree regeneration; wildfire is not a major problem; a high percentage of the land is occupied by muskegs; and high winds cause heavy losses of potential timber by windthrow.

Southeast Alaska is far enough north to experience a wide range in daily hours of possible sunshine during the course of a year, which lessens the daily temperature fluctuation (Watson et al. 1971). During long hours of sunlight in the summer, there is only a brief nighttime period of radiational cooling. During the shortest days in winter, the reduced hours of sunshine and low sun angle result in little surface heating, and most of what is received is lost through reflection. Even on the longest days, the sun is so low that there is no pronounced peak in surface heating (Watson et al. 1971). The other major temperature effect is the moderating influence of the open waters of the inland passage. These waters are warmed by the circulation of the Alaska current, which is an eddy off the Kuroshio Drift (Johnson and Hartman 1969). Sea temperatures off southeast Alaska range from about 55° F. in the summer to about 42° F. in the winter. The coast is free of ice except in protected waters.

The Coast Mountains that back southeastern Alaska effectively interrupt the surface atmospheric circulation (Fitton 1930). In response, precipitation generally accumulates to between 60 and 200 inches a year (extreme values for means are 26 inches at Skagway and 211 inches at Little Port Walter) as steady, light to moderate rain or snow during 220 to 230 days in the year. June is the driest month, 4 inches normal; October the wettest, almost 12 inches of rain (Searby 1968). On the average, cloudy skies occur on 275 days, 43 are clear, and the remainder are partly cloudy.

Maximum precipitation is usually associated with low pressure centers which develop in, or cross, the Gulf of Alaska. The flow aloft is usually either southerly or southwesterly as a result of a trough moving eastward over the Alaska Peninsula area into the Gulf of Alaska (Miller 1963).

The prominent low pressure systems, called Aleutian Lows, make southeast Alaska an essentially stormy area, winter and summer. A normal storm track along the Aleutian Island chain, the Alaska Peninsula, and all the coastal area of the Gulf of Alaska exposes these areas to most of the storms crossing the north Pacific (Searby 1968). The Aleutian Lows are not the developmental areas for these cyclones, but a favorable channel through which to pass (Fitton 1930). The resultant nearly constant east-west zonal circulation dominates throughout autumn and winter and intermittently at other times of the year (Marcus 1964). At times Canadian or arctic high pressure systems spill over the Coast Mountains, bringing northerly winds. From these sources, especially the deep cyclonic depressions, there develops a pattern of windiness that has taken a toll of merchant and fishing vessels, has done considerable structural damage, and has made a mosaic of young even-aged stands following blowdowns of old-growth forests.

Nearly 40 percent of the large daily precipitation occurs in October, with only 1 percent in April, May, and June. The probable maximum 24-hour precipitation ranges from about 20 to 27.5 inches (Miller 1963).

One of the most distinctive climate-related features of southeast Alaska is its glaciation (fig. 3). According to Miller (1967), 43-year

Figure 3.--Mendenhall Glacier, near Juneau, Alaska.

cycles of glacial advance and retreat respond to the warming or cooling trends associated with sunspot activity. During maximum solar activity, the continental airmass warms and expands, forcing the maritime airmass seaward and raising the elevation at which there is snowfall. High-elevation glaciers expand and low-elevation glaciers shrink. With minimum solar activity, the continental airmass cools and contracts, the maritime airmass moves landward, lowering the elevation at which there is snowfall. High-elevation glaciers shrink and low-elevation glaciers expand. Past trends suggest that we are entering a period of cooling.

Daylight throughout the latitudes of southeast Alaska ranges from about 18-1/2 hours to as little as 7 hours. From 6 to 8 percent of the day is twilight and materially lengthens the day in terms of visibility so that useful daylight amounts to 8-1/2 to nearly 22 hours.

Climatic summaries are available in Searby (1968), and U.S. Weather Bureau (1962, 1965). Small scale maps of plotted climatic data were published by Johnson and Hartman (1969). More detailed summaries for certain stations and climatic elements were published by Watson et al. (1971) and Andersen (1955). Daily details for many stations are published monthly and annually by the Environmental Data Service of the National Oceanic and Atmospheric Administration.

The tides of southeastern Alaska are an important consideration in planning log dumping and storage areas, construction of homes, roads, businesses, and recreational facilities.

The mean diurnal tidal range varies from less than 10 feet on the west coast of the archipelago to nearly 17 feet in inland passages. Spring tides, resulting from the combined effects of the moon and the sun, increase the range as much as 40 percent and the neap tides (opposite effect) reduce the range as much as 40 percent. For instance, in 1972 the greatest tidal range at Juneau was from -4.4 feet to 20.6 feet on November 21. The smallest range, 2.8 feet, was on February 8-9 with stages of 7.2 and 10 feet.

GEOLOGY AND SOILS

Southeast Alaska lies within the broad zone of active volcanism and other mountain building processes which rims the north Pacific basin. The region is characterized by deep valleys, steep slopes, and narrow intervalley ridges. Drainage patterns are coarse and strongly controlled by faulting and jointing of the bedrock. Extensive glaciation during the last ice age has modified these features to a large extent, creating characteristic U-shaped valleys, serrate ridges, horn peaks, and cirque basins so typical of recently deglaciated terrain. Glaciation (fig. 3) and mountain building processes are still active in the region today. Vigorous mountain glaciation is presently occurring in the Coast Mountains, and faulting and tectonic uplift have occurred west of Chatham Strait as recently as 1958 (Miller 1960).

Detailed mapping and interpretation of the geologic history of southeastern Alaska are still in beginning stages. Many of the available

data are of a reconnaissance nature and date back to the early part of the century. Detailed interpretation is also hampered by lack of rock exposures and an inadequate knowledge of the geologic record. An excellent analysis of the geologic history of southeast Alaska based on existing data has been prepared by Brew et al. (1966).

The following synopsis of the geologic history of southeast Alaska provides an appreciation for the dynamic nature of the landscape and a framework in which to consider the interaction of the various resources and the various management problems encountered in their use.

EARLY GEOLOGIC HISTORY

Gross topographic configuration of southeast Alaska is a product of (1) widespread deformation, metamorphism and intrusion of thick sequences of interbedded Paleozoic[1/] and Mesozoic[2/] sediments and volcanics and (2) major igneous intrusions at the end of the Mesozoic era (approximately 65 million years ago). The outcrop pattern (fig. 4) is dominated by three northwest-southeast trending belts of sedimentary and metamorphic rocks consisting of gray-green graywackes, conglomerates, and sandstones interbedded with black shales and slates (locally called argillite), and gray-green andesitic flow rocks. Locally, limestones and marbles dominate. The oldest rocks, of Paleozoic age, occupy the center belt, with younger Mesozoic rocks occupying the belts on either side and indicating a broad anticlinal structure which dominates the regional structural pattern.

Igneous rocks, predominantly quartz-diorite, diorite and granite, were intruded during a late Cretaceous-early Tertiary metamorphic period. The igneous intrusions dominate the Coast Mountains and occur in a belt trending northwest-southeast through Baranof and Chichagof Islands toward the St. Elias Mountains. The Coast Mountains constitute a portion of a major batholithic intrusive belt which extends along the entire north Pacific coast (Gabrielse and Wheeler 1961).

Metamorphism of the surrounding rocks is associated with all the igneous intrusions in the region. In addition, there are broad areas which have undergone varying dynamic metamorphism associated with regional folding and deformation. A belt of highly metamorphosed rocks, predominantly high-grade gneisses and schists (locally garnetiferous), extends the entire length of southeast Alaska adjacent to the Coast Range Batholith and was probably formed during intrusion of the batholithic mass. This is the "Wrangell-Revillagigedo belt of metamorphic rocks" first described by Buddington and Chapin (1929). A similar belt of metamorphic rocks makes up the "Wales Group" on southern Prince of Wales Island. A third area of extensive metamorphism includes all of Baranof Island and southwestern Chichagof Island, probably in large part related to intrusion of igneous masses in that area.

Northwest-southeast and north-south trending lineaments and faults of Cretaceous-Tertiary age are prominent features of the regional structural pattern in southeast Alaska (fig. 5). The north-trending Chatham Strait

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1/ 225 to 500 million years ago.
2/ 65 to 225 million years ago.

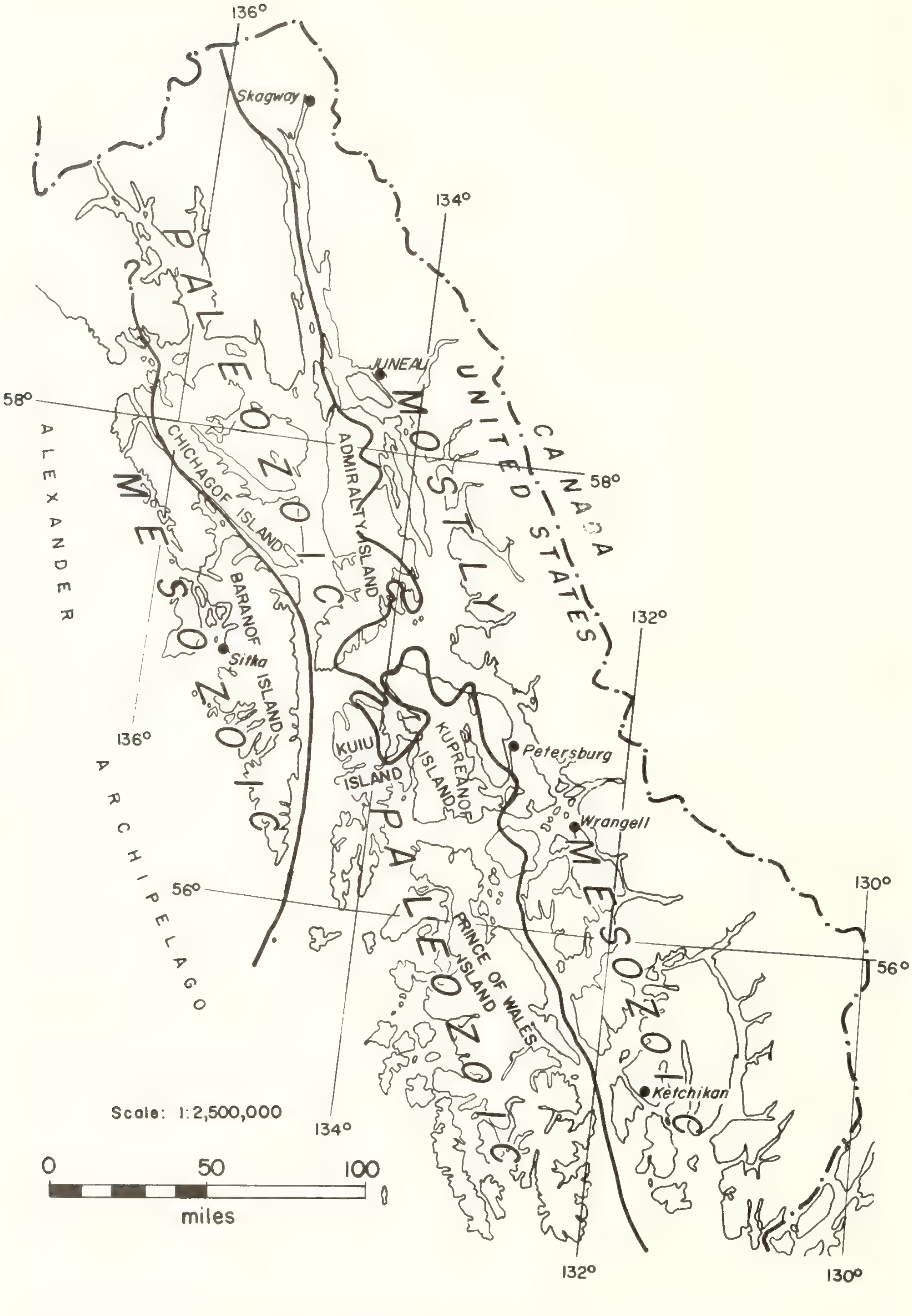

Figure 4.--Major outcrop belts of southeast Alaska (from Brew et al. 1966; used with permission of the publisher, The Canadian Institute of Mining and Metallurgy).

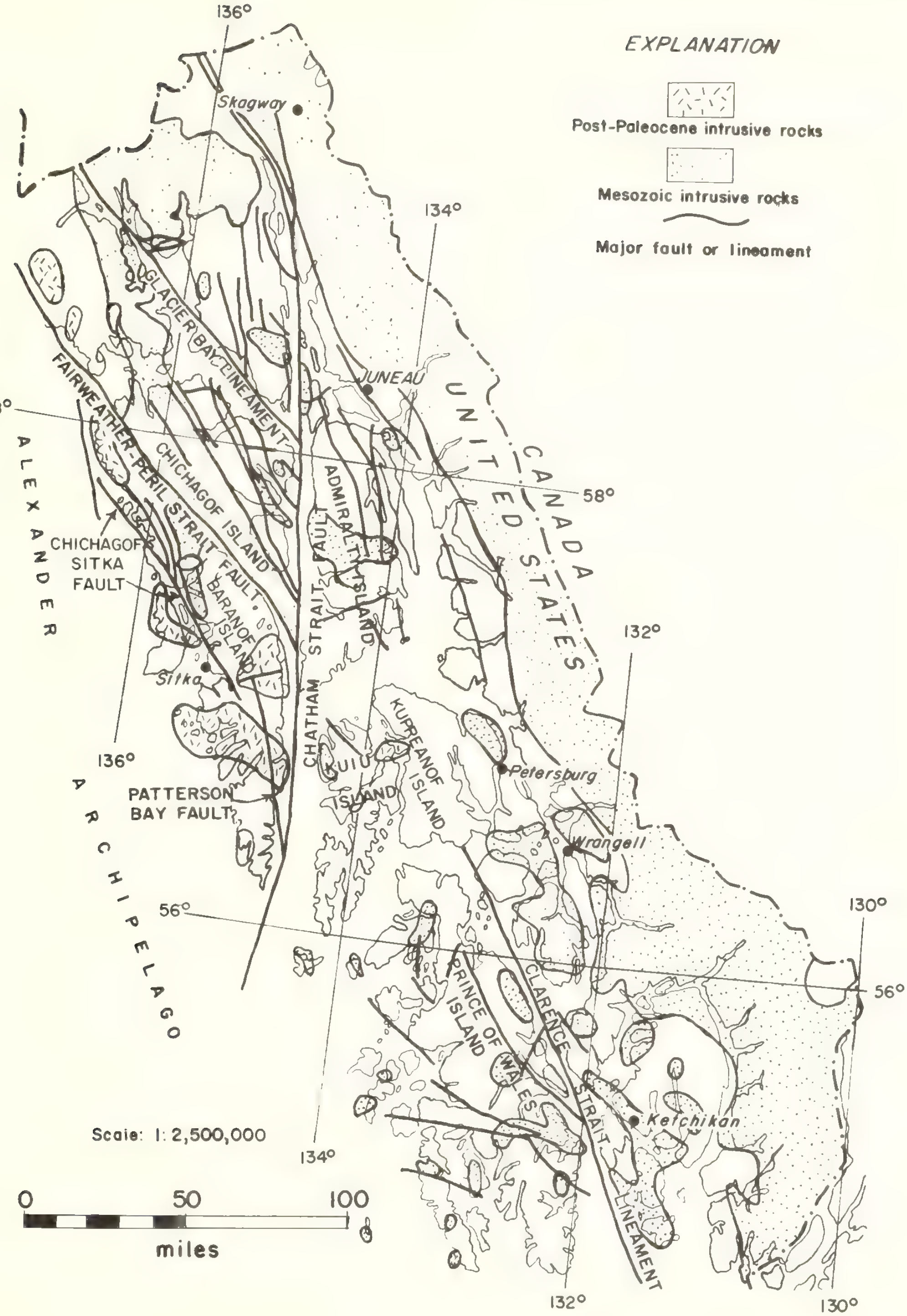

Figure 5.--Post-Paleozoic intrusions and major faults and lineaments of southeast Alaska (from Brew et al. 1966; used with permission of the publisher, The Canadian Institute of Mining and Metallurgy).

Fault dominates these features, extending through Chatham Strait and Lynn Canal for over 250 miles. Approximately 50 miles of offset have occurred along this faultline (Brew et al. 1966). The Fairweather Fault trends northwest-southeast along Peril Strait, Lisianski Inlet, and the western flank of the Fairweather Range and intersects the Chatham Strait Fault at the entrance to Peril Strait. Approximately 18 miles of offset have occurred along this fault. The Chichagof-Sitka-Patterson Bay Fault, trending northwest-southeast, is located along the west side of Baranof and Chichagof Islands. This fault also intersects the Chatham Strait Fault although movement has not yet been quantified or reported in the literature. Many other faults and lineaments exist in southeast Alaska but are difficult to interpret because of lack of detailed mapping and concealment of faulting evidence by fiords and channels.

Following this major period of folding, faulting, intrusion, and metamorphism, tectonic activity decreased in magnitude although local volcanic activity associated with uplift and erosion has continued. During the Tertiary period, such activity produced a thick sequence of sandstones, conglomerates, and andesitic volcanics which were deposited in the central part of southeastern Alaska. These are mainly exposed on Kuiu, Kupreanof, northern Prince of Wales, and southern Admiralty Islands and have remained relatively undeformed.

PLEISTOCENE GLACIATION

Weathering and erosion of the geologic surfaces produced by the late Cretaceous-early Tertiary period of folding, faulting, and metamorphism are primarily responsible for the broad topographic configuration of southeastern Alaska. Subsequent erosion and deposition by continental and alpine glaciers during the Pleistocene epoch (2 million to 10,000 years ago) and by alpine glaciation during post-Pleistocene (Holocene) time have modified this topographic configuration to what it is today.

Southeast Alaska undoubtedly underwent repeated continental glaciations during the Pleistocene epoch, with the continental ice mass in the interior of Canada flowing through the principal valley passes in the Coast Mountains: the Alsek, Taku, Whiting, Stikine, and Unuk Rivers. Unfortunately, evidence of these early Pleistocene glaciations has largely been masked by the later glacial expansions in the region. Almost all evidences of glacial erosion and deposition in southeastern Alaska thus far identified are directly related to the last major glacial advance of the Pleistocene, the Wisconsinan.

The highest levels of glaciation during the Wisconsinan extended from 2,000-3,000 feet in elevation on the outer islands of the Alexander Archipelago (Coulter et al. 1965, Sainsbury 1961) to 6,000 to 8,000 feet in elevation in the Coast Mountains (Miller 1964). This seaward gradient, coupled with sloping berm lines and lower correlative cirque floor elevations in the Alexander Archipelago (Swanston and Miller 1968), indicates an ice surface sloping to the west. The glacier advances during the Wisconsinan must have been via outlet glaciers through the Coast Mountains forming extensive valley ice tongues in the archipelago and leaving large low-level areas to be fed by glaciers from local mountain icecaps on the islands and along the mainland.

Although the overwhelming majority of southeast Alaska lands below 3,000 feet were occupied by ice during the Wisconsinan glaciation, several areas west of the Fairweather and St. Elias Mountains were not (Heusser 1960, Miller 1961, Goldthwait 1963); and there is evidence suggesting that one area on Prince of Wales Island may have escaped glaciation, at least during the last Wisconsinan ice advance (Harris 1965).

RECENT GEOLOGICAL ACTIVITY

A warming of the climate caused a general retreat of the late Wisconsinan ice sheet that occupied southeast Alaska, culminating in the "Thermal Maximum," 6,000 to 7,000 years ago when the mean annual temperature was about 1° warmer than today and precipitation was considerably less (Goldthwait 1966). Glaciers in southeastern Alaska were reduced to nearly their present size or smaller. At this time, rising sea levels, due to melting of the continental ice sheet, inundated many of the glacial valleys and deposited marine terraces at several different levels above the present tide line. A marine beach terrace at an elevation of about 50 feet occurs intermittently throughout the panhandle and may be related to an early postglacial sea level rise.

A slowly cooling trend 2,000 to 3,000 years ago caused many of the mainland glaciers to readvance following the "Thermal Maximum" although not synchronously nor to the same extent. The Glacier Bay ice sheet was probably the most pronounced of these glacial advances, obtaining a maximum thickness of 4,000 feet and extending to Icy Strait. This ice sheet began to retreat 190-270 years ago and has retreated some 70 miles in that time. Dendrochronological studies in the Juneau area have shown that the Taku, Mendenhall, Herbert, and Eagle Glaciers had reached a maximum advance around 1750 (Lawrence 1950). This advance is clearly marked by terminal moraines in front of the Herbert, Eagle, and Mendenhall Glaciers.

A general retreat of southeast Alaska glaciers from their maximum positions is presently occurring. This is not steady, however, and minor readvances of many glaciers have occurred or are occurring (e.g., the Taku, Brady, Lituya, and Hubbard Glaciers).

The northern part of southeastern Alaska is undergoing glacial rebound or readjustment of the land surface to the position it held before it was depressed by the weight of the ice. Rates of uplift range from about 4 centimeters (1.6 inches) per year at Glacier Bay to 2 centimeters (0.8 inch) per year at Juneau (Hicks and Shofnos 1965).

The Chatham Strait Fault and its associated faults to the west are part of the larger Denali-Queen Charlotte Fault zone, a presently active system of strike-slip faults extending along the north Pacific coast (Souther 1970) which almost certainly links up with the San Andreas Fault system in northern California. Its northern extension passes up the Chilkat River, over Chilkat Pass, and along the Shakwak Valley separating the St. Elias Mountains from the Yukon Plateau.

The region west of the Chatham Strait Fault is a zone of high seismic activity with a well-documented record of late Cenozoic to recent movement along the Fairweather and related faults (Page 1969), the most recent being the Lituya Bay earthquake of 1958 which produced a right lateral shift and

vertical uplift of 30 feet. In contrast, the region to the east of the Chatham Strait Fault has low seismic activity and has remained relatively stable.

The most recent major volcanic activity documented in southeastern Alaska occurred between 6,000 and 9,000 years ago and was associated with the eruption of Mount Edgecumbe on Kruzof Island, near Sitka, which deposited volcanic ash and lapilli as far east as Sitkoh Bay on Chichagof Island. More recent volcanic activity is evidenced by a basalt flow which passed down Lava Fork and partially dammed Blue River, a tributary to the Unuk River northeast of Ketchikan. This flow originated on the Canadian side of the Alaska-Canada boundary and is probably less than 120 years old. Active hot springs, indicating the presence of hot igneous rocks below the surface, occur at scattered locations throughout southeast Alaska. The best known hot springs are at Bell Island and Tenakee.

As a result of these geologic influences, valley walls are often greatly oversteepened, frequently above a stable angle for the soils on them, and subject to frequent natural debris avalanches and debris flows (fig. 6). Soils are youthful, shallow, poorly developed, and low in

Figure 6.--Debris avalanche in the Marten Creek valley, Alaska.

available nutrients due primarily to lack of extensive weathering of bedrock and glacial till deposits. Drainage density is low, and the angular drainage pattern is indicative of a youthful stage of development with maximum control exerted by bedrock structure. Few new stream tributary channels have been developed since deglaciation because of the coarse, permeable nature of the soils and the recent exposure of the land surface. Most existing drainages occupy preglacial channels controlled by faulting and jointing. Stream gradients vary widely and may range from 10 to 1,000 feet per mile. In large valleys, the tributary gradients decrease abruptly once the main valley floor is reached, and an agraded (depositional) condition with braided or meandering channels is frequently encountered in both the lower tributaries and the main stream.

MINERALS AND MINING

An epoch of intense mineralization closely followed intrusion of the Late Cretaceous-Early Tertiary batholithic rocks in southeastern Alaska. Veins of metal-bearing quartz and disseminated metal in the country rock lie along the contacts of the igneous intrusions throughout the region. Historically, the principal economic minerals have been gold and copper, but nickel, chromite, magnetite, uranium, and lead-zinc also occur and have been worked commercially. Some silver and platinum have also been produced as milling byproducts.

The most highly mineralized areas lie in a narrow strip of sharply folded paleozoic sediments adjacent to the Coast Range Batholith, in the country rock adjacent to intrusions along the west coast of Chichagof Island, and adjacent to intrusions on Kasaan Peninsula on Prince of Wales Island. Most mining activity has been concentrated in these highly mineralized areas, although many smaller mineralized zones have been identified and worked during the history of mining in the region. Some of the earliest discoveries were gold placers along streams leading from the coastal mountains, but principal production has come primarily from lode deposits. There has also been extensive quarrying of limestone and marble on Prince of Wales and Kosciusko Islands.

Probably the best known deposits in southeastern Alaska are the gold-quartz veins adjacent to the Coast Range Batholith, in the so-called "Juneau Gold Belt" extending some 175 miles between Windham Bay and Berners Bay. Within this belt, two of the most productive mines in southeast Alaska operated, the Alaska-Juneau and Treadwell Mines located respectively on the mainland and on Douglas Island near Juneau. Gold-quartz veins in the "Chichagof Gold Belt" were also important producers with most of the production coming from the Chichagof Mine near Klag Bay and the Hurst-Chichagof at Kimshan Cove, both on the west side of Chichagof Island.

For many years, copper was second only to gold in production in southeastern Alaska, coming primarily from the Mount Andrew, Mamie, Poorman and It Mines on Kasaan Peninsula; the Rush and Brown Mines near Karta Bay; and the Jumbo and Copper Mountain Mines near the head of Hetta Inlet, all on Prince of Wales Island.

Silver and lead have been produced primarily as byproducts of gold milling although the mines in the Hyder District were and still are primary silver producers. The principal source of lead was as a byproduct of the Alaska-Juneau Mine operation.

Platinum metals have also been produced as byproducts, most of the output coming from the copper mines of Kasaan Peninsula.

The output from all mines was shipped south to Canada and the United States for refining and smelting.

In general, mining in southeastern Alaska has been an on-again, off-again operation. The ores characteristically occur in discontinuous veins and lodes so that it is difficult to accurately predict production levels or to estimate reserves. Throughout the history of mining in the region, profits have been marginal and greatly dependent on the prevailing market price of minerals. The Chichagof mines have operated intermittently since they were first discovered. The Kasaan Peninsula mines achieved their greatest copper production because of high demand for that metal during the First World War; they declined steadily after that. Their last reported production was in 1938. The Alaska-Juneau (fig. 7) and the

Figure 7.--Alaska Juneau Mining Company mill at Juneau, Alaska.

Treadwell are the only mines that were able to maintain more or less continuous production for any length of time, largely because of low labor costs and the high volumes of ore they were able to handle. The Treadwell closed in 1917, after 30 years of operation, when an invasion of seawater filled most of the mine tunnels. The Alaska-Juneau was closed during the Second World War and never reopened.

During the midfifties a uranium-thorium deposit was discovered in the vicinity of Kendrick Bay on southern Prince of Wales Island. This deposit, centered at the Ross-Adams property on Bokan Mountain, was developed and operated for approximately 3 years (1955-58). It was closed down in 1958 due to difficulty in smelting the ore. It was reopened again in 1970 and the remaining commercial ore removed. Inlet Oil Company is currently operating a barite mine in Duncan Canal near Petersburg. The barite is shipped to Kenai where it is ground and bagged for drilling mud.

There were several commercial mining ventures active in southeast Alaska during the summer of 1971, but these are small and are not expected to operate for any length of time.[3/] There is a small lead-zinc-silver operation on George Inlet northeast of Ketchikan. El Paso Natural Gas has found a good lead-silver property near Hyder and has recently recorded a large group of claims near Boundary Lake east of Juneau. The Marconi Corporation is proposing to develop a taconite plant to process magnetite iron near Port Snettisham. Various companies are actively prospecting for copper on Kasaan Peninsula, and Newmont Mining is currently drilling for copper and nickel in Glacier Bay National Monument.

Complicated structure and large areas of igneous rock make much of the southeastern Alaska panhandle unfavorable for the occurrence of petroleum in commercial quantities. Miller (1959), however, defines three areas lying within the Tongass National Forest, in which it may be geologically possible to find petroleum: (a) Heceta Island area, (b) Keku Islets area, and (c) Gulf of Alaska between Cape Yakataga and Cape Spencer.

No verified oil finds have been made in the Heceta Island-Keku Islets areas, although there was an unverified report of an oil seep several miles inland from the head of Murder Cove on Admiralty Island.

Oil and gas seeps are abundant along the shore of the Gulf of Alaska, especially in the Yakataga and Malaspina Districts. In the Yakataga District, oil seeps occur at or near the faulted crest of the Sullivan Anticline, which lies near the coast. Large oil seeps also occur in the Samovar Hills at the north margins of the Malaspina Glacier, and oil seeps and films have been reported near Icy Bay, Lituya Bay, Yakutat Bay, and Cape Spencer.

Although mining is presently in a relatively dormant state, there is considerable potential for future impact on resource patterns if major revitalization of the mining industry occurs. The principal impact of mining activity on forest resource management has been and probably will continue to be related directly to the mineral access rights stipulations of the Federal mining laws. An excellent discussion of the broad impact of current law on public land management has been prepared by the Stanford

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3/ Wesley Moulton, Regional Mining Engineer, Region 10, personal communication.

Environmental Law Society (Condon and Jackman 1971) and should be pursued for a more detailed discussion. Under the provisions of the current law (Mining Law of 1872), mineral locators are able to explore for, occupy, and obtain patent to valuable mineral deposits on the public domain, including Forest Service lands, and to purchase, for a nominal price, the land on which these deposits are found. In addition, locators have the opportunity to patent up to 5 additional acres of nonmineral land for a millsite. On the basis of this law, the prospector has free access to and is unrestricted in his activities on forest land as long as he is diligently exploring for or mining mineral deposits. For all practical purposes, the activities of the prospector and hard rock miner lie outside any comprehensive land use plans and are not subject to regulation by the forest land manager. Thus, any land management policies implemented by the Forest Service in this area are continually subject to displacement by a mineral claimant.

Several other ramifications of the Mining Law of 1872 make forest land management particularly difficult in southeastern Alaska. There is no easy way to discover which Forest Service lands are subject to either valid or invalid mining claims. The law requires that the claim be recorded on the local land records but does not require notification of the Federal Government. It is also difficult to challenge or remove invalid or abandoned claims. According to Condon and Jackman (1971) the Federal Government can contest a claim only if it can prove actual abandonment or that no valid discovery has been made. It cannot contest a claim for failure to comply with State location requirements. This is a difficult and cumbersome process in that the Government must first show a prima facie case of invalidity before the burden of proof shifts to the claim holder.

These laws have recently undergone close scrutiny by the Public Land Law Review Commission and others,[4/] and several recommendations have been made for basic changes and reforms of administrative policy providing Federal land managers with some positive control over entry onto the public domain. If such recommendations are enacted into law, the forest land manager may gain the power to balance other public land values against the need for a particular mining activity.

SOILS AND SOIL DEVELOPMENT

The major ice recession which occurred about 10,000 years ago was "time zero" for most soils of southeast Alaska. Compact glacial till, evidently formed from the great pressure of the ice on overridden (basal) till, is extensive up to about 1,500 feet in elevation in many U-shaped valleys.

[4/] *One-third of the Nation's land*, report by the Public Land Law Review Commission, June 1970. 122 p.

U.S. Department of the Interior, "The Mining Law - An Antique in Need of Repeal," a recommendation for repeal of the 1872 Mining Law, submitted to the Public Land Law Review Commission in January 1969.

Northcutt Ely assisted by Albert Chandler, *"Hard Rock" Mineral Policies on Federal Lands*, prepared for the Mining and Metallurgical Society of America, May 1969.

The existence of the compact glacial till in the landscape is difficult to determine; however, it occurs intermittently depending on the movement of past glaciers and the localized pressures exerted by the ice. Most mineral soils are derived primarily from ablation till, even those over bedrock. Till deposits become thinner at higher elevations, evidently due to the lesser volumes of ice to melt and deposit loads of till. Till deposits also tend to be thicker on south- and west-facing slopes than on north- and east-facing slopes.

Postglacial ash and pumice deposits are extensive on southeastern Revilla Island and the Kruzof-northern Baranof-southern Chichagof Islands area. Ash from Kruzof Island has been dated as about 9,000 years old. Soils formed in these volcanic ash materials are moderately well-developed Spodosols, many of them with a heavy iron concentration zone called a plastic horizon. They are forested, and their landscapes contain many natural landslide areas, presenting a variety of management problems.

Moderately well-developed soil profiles occur on the fine silt and clay sediments of the marine terraces which occur throughout southeast Alaska at various elevations up to 500 feet. They are forested with conifer vegetation and not easily identified in the landscape without spot checking.

Because of an overburden of glacial till, bedrock plays a lesser role in soil development. Rocky types vary greatly; there are extensive areas of granitic, metamorphic, volcanic, and calcareous rocks. Bedrock, except for some rocks of unusual mineralogy, has little influence on soil occurrence, except as it influences soil drainage and the distribution of alpine areas. Granitic rocks are generally more massive and resistant to glacial erosion than the other rock types; consequently, they often form the more extensive mountain systems with widespread alpine areas. They also tend to have relatively high proportions of very poorly drained (muskeg) soils. Marble and limestone areas, with their extensive fracturing and good subsurface drainage, often have very low proportions of poorly and very poorly drained soils, unless they are overlain by compact glacial till.

The five basic soil forming factors--time, climate, parent material, vegetation, and topography--all have influenced soil development in southeast Alaska, but climate appears dominant.

Temperature greatly influences the rate of organic matter decomposition on the forest floor and the degree of incorporation of organic carbons into the soil. Also, microbiological activity is an important factor in soil development and the availability of nutrients for plant use. Soil temperatures greatly influence biotic activity. When soil temperature reaches about 43° F., biotic activity slows drastically to almost nil. High rainfall, cool summer temperatures, a short growing season, and moderately low soil temperatures all contribute to the accumulation of organic material on the surface and in the soils of southeast Alaska. The organic mat which accumulates on the surface ranges from 6 to 10 inches thick. Soils which have developed are high in both organic carbon and iron and relatively low in clay content (Stephens 1969b). This is due in part to the influence of climate.

The average soil contains approximately 10 percent organic matter and 12 percent iron oxides, which strongly attract and hold water. This plus frequent and high rainfall keeps these soils fairly moist most of the time. Because of the high content of both iron and organic matter, plus the high rainfall, many of the soils in southeast Alaska have developed thixotrophic properties. They are commonly referred to as "quick." The soil structure breaks down under stress. The breakdown itself may be caused by one of several things such as agitation, shearing, or excess weight upon the soil material. Thixotrophy is a reversible gel-sol transformation, and the soil material will set back up after a rest.

The occurrence of forest vegetation on raw glacial till parent material varies, but generally Sitka alder with willow and cottonwood will dominate the site soon after the material is deposited. Observation of the plant succession in front of glaciers indicates that Sitka spruce gradually overtops the shrubs; with 100 years of vegetation establishment, a dense Sitka spruce forest will dominate the site (Stephens 1969a). Soil development starts with the establishment of the first plants. Organic matter, nitrogen, and other plant nutrients build up in the soil as the vegetative succession takes place. After about 75 years, soil development has proceeded to the point of a thin, bleached horizon apparent immediately below the surface organic layer.

In the first 10 to 60 years of soil development, nitrogen accumulates in the mineral forest floor system at an apparently steady rate of about 32 pounds per acre per year. After 60 years, there is a marked reduction in the rate of accumulation of nitrogen; but the process does continue as the soil develops. Organic carbon will follow a somewhat similar trend (Crocker and Dickson 1957). As mineral soils develop in southeast Alaska, a series of things happens. The soil reaction (pH) goes from alkaline (pH 8.0) to slightly acid (pH 5.0) within 30 to 50 years. There are also increases in organic carbon and nitrogen. Alder appears to be the main plant contributing to these nitrogen increases.

An absolute loss of nitrogen from mineral soil is associated with the elimination of alder and the emergence of the spruce forest (Crocker and Major 1955). However, most of this nitrogen may be retained within the wider vegetation-soil system, and little or none of it may be lost altogether.

With the passing of 200 to 250 years, a weakly developed soil profile called a Spodosol is formed. Spodosols (Podzols) are extensive in southeast Alaska. All mature mineral soils under timber have strongly developed spodic (Podzol B) horizons. The better drained Spodosols have remarkably similar properties regardless of the parent material (Stephens et al. 1970).

Precipitation in southeast Alaska exceeds calculated evapotranspiration throughout the year in most of the area. Mainly because of the Late Pleistocene glaciation, the landscape also has many depressions and extensive impermeable soil layers (commonly compact glacial till or water-laid glacial flour). As a result, there are extensive areas of organic soils. These soils are classified as Histosols, commonly called "muskegs" in southeast Alaska, and are found in a wide variety of landscape positions. They are found on nearly flat slopes and slopes of 20° to 22°.

These organic soils are saturated or nearly saturated with water most of the year. At the extreme, they may be only a mat, floating on water.

The muskegs of southeast Alaska vary in depth, composition and vegetative relations. The depth of organic soil material ranges from less than 2 feet to over 40 feet. They may be composed of sphagnum peat, sedge peat, or muck, usually with some component of wood.

Vegetation growing on a muskeg is related to the organic material present, which in turn is related to water table regime and movement. In addition to the open muskegs, a large acreage of wet organic soils supports forest vegetation (Stephens et al. 1970).

Organic soils in southeast Alaska include alpine organic soils, well-drained organic soils derived from forest litter over bedrock or gravel, and wet organic soils derived from various vegetative materials. The wet organic soils below the alpine can generally be placed into four groups: (1) poorly decomposed moss peat (Kogish Series), (2) moderately decomposed sedge peats (Kina Series), (3) poorly decomposed sedge peats (Staney Series), and (4) mucks over peats (Maybeso and Kaikli Series).

Of these four major kinds of wet organic soils, only those of the last group (Maybeso and Kaikli soils) support forest vegetation; they represent about 10 percent of the landscape. The others are muskeg, that is, the vegetation on them is dominated by sphagnum mosses or sedges or both, with low shrubs and forbs and only scattered trees. They represent about 14 percent of southeast Alaska's landscape.

The wet organic soils throughout southeast Alaska comprise about 24 percent of the landscape. Estimates derived from timber inventory of southeast Alaska indicate that about 36.2 percent of the area is included in alpine meadows, brushfields, rock, snow, and icefields. The remaining 39.8 percent is comprised of soils derived from glacial till and residual bedrock. This includes soil types which support conifers, alder brush, and natural grassland.

The thick organic mat which accumulates on the surface of these glacial tills and residual soils is a storehouse of plant nutrients. The depth of tree rooting is confined primarily to this organic mat and the upper 12 inches of mineral soil.

FOREST RESOURCES

VEGETATION TYPES

The forest of southeast Alaska is a segment of the continuous coastal, temperate rain forest extending along the Pacific rim from northern California to Cook Inlet in Alaska. Viewed from a passing ferry, the rugged mountainsides along the inside passage appear to be covered with unbroken conifer forests from the water to timberline. From the air, however, the forest zone is a mosaic of various densities, crown sizes, subtle colors, and interspersed openings. Most of the forest consists of old-growth stands undisturbed by man. Differences in external appearance are due to stand age, species composition, and tree vigor. Stands which

have remained undisturbed for centuries have a ragged texture because they include trees of various ages, sizes, and conditions, with many dead tops and snags. Stands which have been disturbed during the last century or two by windthrow, fire, or landslide have a more uniform appearance because they contain trees of more uniform age and size, with fewer snags and defective trees.

In the southern part of southeast Alaska, the forests are primarily western hemlock and Sitka spruce, with scattered western redcedar and Alaska-cedar. In the northern part, the percentage of hemlock increases somewhat and the cedars are less important. Western redcedar extends only to the northern shore of Frederick Sound, and Alaska-cedar is often found only as a small tree in swamps or muskegs. In the northern portion of the area, mountain hemlock becomes more prominent. Other commonly found species are red alder (along streams, on landslides, and on other highly disturbed areas), black cottonwood (in major mainland river valleys), and lodgepole pine (adjacent to muskegs and on other poorly drained sites). Less common species include subalpine fir and Pacific silver fir.

The best stands of timber generally are found near tidewater with stand heights, volume per acre, and quality diminishing progressively up the slope. The terrain is predominantly steep, rugged, and broken.

Interspersed with forest stands are openings, hidden from view of the water but prominent from the air. These are "muskegs" or bog plant communities growing on deep peat and dominated by sphagnum mosses, water-loving plants such as sedges and rushes, and ericaceous shrubs. Tree growth is sparse within the muskegs and consists mostly of hemlock and lodgepole pine in scrub form. Muskegs provide suitable habitat for many plants with edible berries, give welcome scenic viewpoints for the foot traveler, and help to regulate streamflow.

Between the muskegs and dense forest are more open forest stands growing primarily on organic soils (Stephens 1969b). Tree growth is slow and tree form often poor in these stands. Alaska-cedar, mountain and western hemlock, lodgepole pine, and Sitka spruce are important species in this forest community. The open canopy allows sufficient light to reach the forest floor to support dense understory vegetation of blueberry, huckleberry, rusty menziesia, other tall shrubs, and numerous small vascular plants. These stands are very important for wildlife habitat.

Above timberline (generally 2,500 to 3,000 feet in elevation) the alpine zone is dominated by heaths, grasses, and other low plants. Plants such as deer cabbage cover wide areas and form excellent summer range for deer. Occasional trees occur, often with stunted or shrublike "krummholz" form, due to adverse growing conditions. The alpine area provides many fine recreational and esthetic opportunities.

A notable feature of southeast Alaska is the abundance of plant life. Except for steep cliffs, scarcely any area remains devoid of vegetation. Even rock, which in a drier climate would be bare, is soon colonized by mosses, small plants, shrubs, or trees.

Southeast Alaska's forests contain fewer tree species than do the coastal forests to the south, and species diversity decreases with

increasing latitude. Nine conifer species and 22 broadleaf species attain tree size. Of these, four species are sought for commercial harvest: western hemlock, Sitka spruce, western redcedar, and Alaska-cedar. Mountain hemlock is logged along with western hemlock when encountered in mixed stands. The wood is equal in all respects to western hemlock, and it is often difficult to tell the two species apart. Pacific silver fir and subalpine fir occur in limited areas and may be cut although neither species is sought out for harvest. Lodgepole pine is used locally for firewood and for Christmas trees but is seldom found in dense commercial stands and rarely cut. Black cottonwood has been harvested occasionally and tested for use in dissolving pulp but is not being harvested today. Red alder is used locally for firewood, carving, and smoking fish. Alders are capable of fixing atmospheric nitrogen and so are valuable in improving soil fertility.

The forests contain many shrub species--Viereck and Little (1972) recognize 72 species as most important. Many of these shrubs are characteristic of the dry interior and appear in southeast Alaska only in the drier transition zones at the head of Lynn Canal and Portland Canal. At present, berries are the only shrub products gathered commercially, and then only on a limited scale. Berries are also used extensively by local residents.

WOOD INDUSTRIES

Before the white man came, southeast Alaska was inhabited by Tlingit and Haida Indians. These original residents developed a culture based on products from the sea and forest. They relied on the sea primarily for food and for travel between their widely spaced villages and hunting or fishing grounds, but their mastery of the sea was made possible by material from the forests. They hewed large canoes up to 60 feet in length, the best and largest made from western redcedar. Inferior or smaller ones were made from Sitka spruce or black cottonwood. Alaska-cedar provided paddles; and cedar bark, the sails and lines.

Canoes were usually made in the winter. A hole was cut at the base on on the windward side of a large standing tree and a fire built at this point. The fire was kept burning until the tree toppled. Canoes were then hewed to shape with an adze with the help of fire.

Houses were of cedar or spruce handsplit planks covering log frames, with a tiered wooden floor surrounding a central firepit. Houses were clustered in villages where many families lived during the winter. Cedar totem poles in front of the houses kept alive the memory of important historical events or legends.

Trees furnished most of the household, personal, and ceremonial articles needed. Bentwood boxes in a variety of sizes were used for storage of food and equipment. Dishes and other utensils were carved from alder, spruce, or cedar, as were ceremonial masks, drums, and rattles. Bows, spears, fishhooks, and numerous other weapons or tools were of wood. Baskets and hats were woven from split roots of Sitka spruce, and cedar bark provided mats, clothing, ropes, and baskets. Firewood was always in demand for cooking and heat, and for drying or smoking fish and meat.

The first demand for timber by white men came with Russian colonization. Under the direction of Alexander Baranof, a colony was founded at Yakutat in the last few years of the 18th century. Logs were needed for construction of a fort and dwellings as well as for firewood.

In 1799 the Russians attempted to establish a colony near the present site of Sitka. Logs were cut for building a fort, and lumber was sawed for building a boat. The venture was short-lived, however, and in 1802 the fort was destroyed by hostile Indians and the boat was burned while still on the ways.

The following year, Baranof ordered two boats to be built at Yakutat for use in recapturing Sitka, and in 1804 these two ships, the 100-ton *Yermak* and the 85-ton *Rostislaf* were completed and put in service (Bancroft 1886).

In 1804 Baranof led a punitive strike against the Sitkans and a new post was established at the present site of Sitka. This time the colony was successful. Logging began immediately to supply logs and lumber for construction of a fort and magazine, and for building a ship which was launched the following year.

A foundry was built, the only one on the Northwest coast for many years, and a supply of charcoal was needed. Stands of hemlock and spruce along Indian River were clearcut for charcoal, which was produced on the spot. Charcoal mounds may still be seen in this area, now within the Sitka National Monument. Some of the earliest studies of tree growth in Alaska were done in the young stand which came in following this early clearcutting.[5/]

The colony prospered, and new construction required a continuing supply of logs and lumber as well as a constant supply of firewood and charcoal. Shipbuilding was an important occupation at the new colony and continued until 1867 when Russian holdings were transferred to the United States. During much of this period, no other shipbuilding facility existed on the Northwest coast. Alaska-cedar was favored for hull construction because of its durability, and selective logging for cedar took place along tidewater as far distant as Peril Straits. It was reported later that Russians had exhausted the accessible supply of cedar near Sitka.

At first, lumber for the growing colony was hewn or sawn by hand, but waterpowered sawmills soon appeared. The first Alaskan sawmill is thought to have been built at Redoubt Bay near Sitka in 1833. It first operated by waterpower, then was converted to steampower in the 1850's. Lumber was sawn for export as well as for local use, and it is probable that a cargo of lumber carried to Chile in 1839 by Captain Etolin was sawn at this mill (DeArmond 1946).

Sometime before 1853, a second sawmill was built at Sawmill Creek about 5 miles from Sitka and a third at Sitka. About 3,000 board feet of lumber were produced daily by the Russian mills, for local use and export.

5/ R. F. Taylor. An investigation of tree growth on the Sitka charcoal mounds. Unpublished report on file at Forestry Sciences Laboratory, Juneau, 6 p., 1934.

Records show that lumber was exported to Chile, Macao, and Canton. Sawdust was also used for packing ice which was cut at Swan Lake near Sitka for shipment to San Francisco during the California gold rush of the early 1850's.

Early Russian logging methods were primitive. Trees were cut with axe or saw, and logs were moved by jacks, levers, or pulleys. Most logging was done on a selective basis, and only high-quality trees of a size that could easily be handled were cut, except close to Sitka where several small areas were clearcut for firewood and charcoal.

After transfer of Alaska to the United States in 1867, use of local timber gradually increased as canneries and towns were built. Many pilings were used to build the canneries over the tideflats. Most logging was by handline and A frames in stands easily reached from protected shores. The areas logged were small, and in many cases only choice trees were taken. Many very large logs as well as small logs and poles were used in the construction of fishtraps.

During World War I, high-quality Sitka spruce lumber suddenly came into demand for construction of military aircraft. Some timber was cut for this purpose near Howkan late in the war, but the operation was plagued with problems. Only a small amount of lumber was exported, and the operation was generally unsuccessful. Altogether during the decade from 1910 to 1920, some 4,000 sales of timber totaling 420 million board feet of sawtimber and piling were made on the National Forest lands in Alaska (Greeley 1920).

Soon after the First World War the Forest Service began reconnaissance of the pulp timber resource and began efforts to attract the paper industry to southeast Alaska. Pulp operating units were laid out, inventories were made, and regional development of the pulp timber resources was planned (Smith 1921). Soon industry became interested, and a sale was made. In 1920 the Alaska Pulp and Paper Company was supplied with 100 million board feet of timber on Admiralty Island and the adjacent mainland, and mill construction began at Port Snettisham near Juneau. This mill operated for about 2 years but was forced to close because costs proved too high for profit.

In 1923, six sawmills were cutting lumber in large quantities for local use and export. Logs for these mills came from trees up to 225 feet tall and 8 feet in diameter growing in stands of pure spruce (Heintzleman 1923). Heintzleman, then assistant district forester with the Forest Service at Juneau, believed that the spruce lumber industry could not be expanded until extensive pulpwood logging operations were started and the many large isolated spruce trees growing with the smaller pulp timber became accessible. He described the forests as being primarily suited for pulp and paper but recognized a large potential for sawtimber production as well.

In 1926, legislation was enacted which gave the Department of Agriculture discretionary power over export of timber from Alaska. The Department's position was clarified in 1928 and remains generally in effect today in that primary manufacture of timber in Alaska is required so as to insure the development of a stable year-round industry.

Interest developed on the part of the pulp industry, and two pulp sales were made in 1927. Substantial initial development work was done, but neither venture advanced to the point where mill construction began. With the market collapse of 1929 and the following depression, plans were abandoned and both sales were cancelled by mutual consent in 1933. From this time until the beginning of World War II, only sporadic interest in pulp development continued (Bruce 1960).

During World War II, Sitka spruce lumber again came into demand for military aircraft. In response the Alaska Spruce Log Program was set up as an agency administered by the Forest Service in June of 1942, and the program continued into early 1944. Total output was 38.5 million board feet of high-grade spruce that was sent to the States and 46 million board feet of grade 3 spruce and hemlock which went to local mills.6/

Several sawmills continued to operate, cutting Sitka spruce and Alaska-cedar for local use and export. In 1953, a small plywood plant began production in Juneau. Sitka spruce plywood was produced and was well accepted. Large, high-quality logs were required, and some were rafted from as far away as Kosciusko Island, some 230 miles distant by water. The venture had financial difficulties, shut down in 1955, and burned to the ground 4 years later without reopening.

Efforts to establish a pulp industry were finally successful, and in 1947 preliminary award of a 50-year sale of 1.5 billion cubic feet (8.25 billion board feet) of timber from an allotment on Prince of Wales and Revillagigedo Islands went to the Ketchikan Pulp Company of Bellingham, Washington. Final terms of the sale contract were signed in July 1951. Construction of a pulpmill was completed at Ward Cove near Ketchikan in 1954. The mill was dedicated in July 1954 and represented the culmination of years of effort to bring the pulp industry to Alaska.

Within 3 years after opening of the Ketchikan Pulp Company mill, the Forest Service entered into three additional long-term agreements which provided for pulp development in Alaska (Bruce 1960).

In June 1954 the Forest Service made a preliminary award for a 50-year sale to Pacific Northern Timber Company of Wrangell for timber located in the vicinity of Petersburg and Wrangell. Terms of the contract called for building a sawmill by 1957 and a pulpmill by 1962 (Greeley 1954).

A sawmill was built, the first in Alaska designed for cutting hemlock. The company soon ran into difficulties and the mill closed. The sale was taken by the Alaska Wood Products Company, now affiliated with Alaska Pulp Company of Tokyo. Terms of the sale were modified several times, the mill redesigned, and at present the sale agreement is for a total of 693 million board feet of timber, with the only construction requirement being for a sawmill.7/

6/ Lawrence Rakestraw. History of the Alaska Region, U.S.F.S. Chapter VI. Manuscript on file, Regional Office, USDA Forest Service, Juneau.

7/ Pacific Northern Timber Company Contract No. A10fs-1283, dated 6/9/54, with modifications. On file, USDA Forest Service, Juneau.

In 1957 the Alaska Lumber and Pulp Company was awarded 50-year cutting rights to 5.25 billion board feet of timber located on Baranof and Chichagof Islands.[8] This company opened a high-sulpha cellulose plant at Silver Bay near Sitka in 1959.

A third 50-year sale for timber on Admiralty Island and the mainland near Juneau and Yakutat was awarded to Georgia-Pacific Company in 1955, but the company did not go through with its plans to build a mill. A new sale of 8.75 billion board feet of timber in approximately the same location was awarded to the St. Regis Company in 1965, the largest timber sale in Forest Service history (Lockhart 1966). The St. Regis Company later abandoned development plans, and in 1968 the sale was transferred to the U.S. Plywood-Champion Papers Co., Inc. In 1970 suit was filed by the Sierra Club and coplaintiffs to stop the sale (Adasiak 1971, Miller 1971), and the case is still in litigation.

To summarize the development of the present timber industry, use of the timber resource by the Indians and Russians was slight, and until nearly the turn of the century timber cutting was limited. With establishment of the Forest Reserves and administration by the U.S. Forest Service, continuing efforts were made to establish a sound economic base in Alaska through establishment of a permanent year-round pulp industry. The Forest Service directly supported and often led this effort because regional development was a generally unquestioned ideal.

The need for multiple use of forest land was recognized by leaders of the Forest Service long before the concept became law. Timber production was recognized as the dominant use of land capable of producing good timber growth, but not to the exclusion of other uses. For example, the need to protect fish spawning streams was recognized, and a limited ban on timber cutting along steamer lanes to avoid esthetic damage was imposed. However, only recently have interests other than the timber industry been strong enough to attract national attention, and demands for all forest resources have increased greatly. The general level of affluence has risen, and leisure time has increased to the point where many articulate people are now questioning previously accepted economic values. The result is that now the Forest Service is no longer in the position of trying to establish a timber industry but is increasingly in the position of acting as arbitrator between many factions which demand ever greater use of the forest resources.

FISH AND WILDLIFE

The abundant and easily accessible salmon runs of southeast Alaska were a major factor in shaping the settlement patterns as well as the cultural activities of the aboriginal peoples of this area. Most of the many Indian villages were located on or near good salmon-producing systems, and salmon made up the bulk of the food supply. Other fish (e.g., halibut and eulachon) and game (e.g., deer and mountain goat) also were used, but much less than the salmon. The dense forests made game rather difficult to obtain in the quantities necessary for a year-round subsistence. In

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[8] Timber Sale Contract No. 12-11-010-1545, Alaska Lumber and Pulp Co., Inc., 1/25/56. On file, USDA Forest Service, Juneau.

contrast, the annual spawning runs of salmon were easily harvested in a short period of time in the quantities necessary to sustain the natives until the next year and a new salmon run.

The abundance and ease of obtaining salmon during their spawning migrations had another major influence on the aboriginal peoples of southeast Alaska. A few days of effort in catching and preserving the fish (generally by drying or smoking which does not appreciably decrease the food value) left considerable leisure time for the people to develop their arts and crafts to a degree greatly superior to that of the interior tribes who found it necessary to devote much more time and effort to obtaining food (Cooley 1963). The methods which these early peoples used to catch fish were not much different from those used today--traps, weirs, nets, and hook and line.

Many of these early village sites are still occupied today, e.g., Yakutat, Klukwan, Hoonah, Angoon, Sitka, Kake, Wrangell, and Klawak, and fishing is still a way of life but more as a commercial venture than for subsistence.

Game was used by these early peoples both for food and for clothing. In addition, skins of fur bearers such as the sea otter and ermine were used for decoration of clothing and ceremonial objects. The Chilkat Indians used the hair of the mountain goat to make blankets.

In general, however, before the influence of the white man, the use of fish and game resources by aboriginal peoples was primarily for subsistence. Some minor trading of meat and skins took place between tribes, but wildlife supplies were generally unaffected by this limited use.

Discovery and exploration of southeast Alaska by Russians and Americans took place in the middle of the 18th century. Sea otter pelts were soon found to be a much-sought article, particularly in Chinese markets, and the trade for and hunting of sea otter was a major occupation of early mercenaries. By the early part of the 19th century the once abundant sea otters had been all but eliminated from southeast Alaskan waters. Other furs and skins were traded to the white companies, but to much less extent than the sea otter.

In 1878 the first salmon canneries were built in southeast Alaska, and the exploitation of this resource increased rapidly. By 1889 at least 36 canneries were in operation in southeast Alaska. Nineteen of these had been built and put into operation during 1888-89 (Federal Field Committee 1968). The 1890 census stated that fishing operations were located at nearly every point that afforded a commercially profitable supply of salmon. Any means known was utilized to harvest the runs, including barricades at the mouths of the streams.

During the early part of the 20th century, the intense commercial fishing of salmon continued (fig. 8). The Pacific coast became the base of the largest salmon industry in the world, and Alaska was the chief source of fish. Conservation practices on the part of the salmon-canning industry did not share equal weight with the economic issues of the moment, and by the 1940's the fishery began a downward trend which continued for the next two decades. Other fish of importance in southeast Alaska are herring, halibut, sablefish, and shellfish of several kinds.

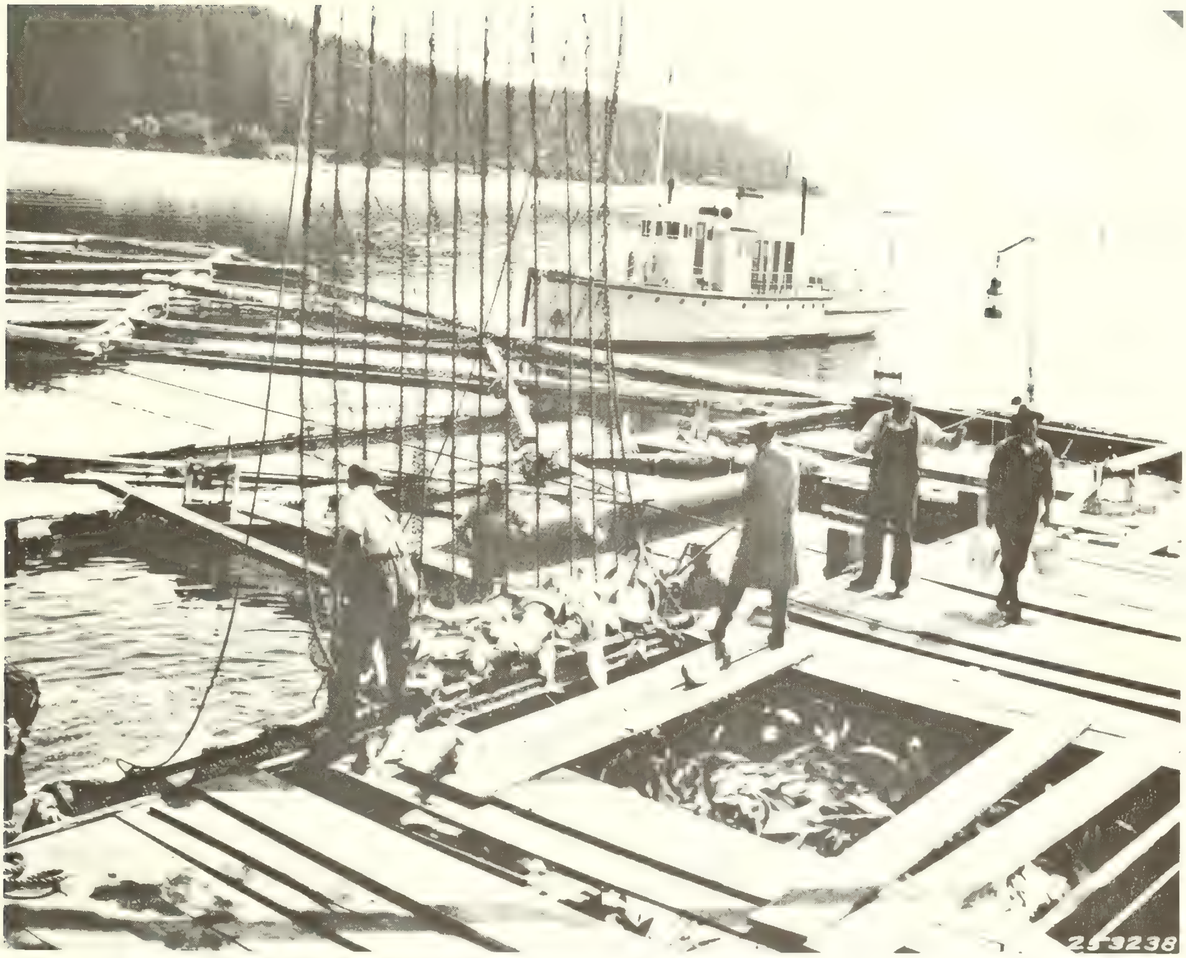

Figure 8.-- Brailing salmon from a floating fish trap in southeast Alaska.

Before World War II, the fur trade still occupied an important position in the economy of the region. Mink, marten, beaver, and otter were regularly trapped, primarily by the indigenous peoples but also by resident whites such as fishermen and others seasonally employed. This fur trapping continued despite fluctuations of market values (Rogers 1960).

The use of other wildlife has become one of recreation and subsistence during the last few decades. The Sitka black-tailed deer provides the major meat supply of many indigenous families. Recreational hunting has assumed a greater importance in southeast Alaska in the past few decades. Nonresident hunters do not often seek deer in their quests for trophies but concentrate on brown bears and, to less extent, mountain goats and moose. Recreational fishing is likewise assuming greater importance in southeast Alaska. Cutthroat and rainbow or steelhead trout are sought in the many lakes and streams of the mainland and the island archipelago. Salt-water fishing for chinook (king) and coho (silver) salmon attracts many residents and nonresidents alike. And many residents enjoy the shellfish--crabs and clams in particular.

Today, the fish and wildlife resources of southeast Alaska are represented by the same species which were present when the area was discovered and first explored.

The five species of Pacific salmon found are: pink (humpback), chum (dog), sockeye (red), chinook (king), and coho (silver).

Halibut, rockfish, king crab, dungeness crab, and several varieties of shrimp and clams are still much sought by local residents, as well as by commercial fishermen.

Recent reintroductions of sea otters into the waters of southeast Alaska have been successful, and this fur bearer may again be a familiar sight in the area.

Although trapping is not as major a livelihood as it was in the early part of this century, nevertheless some fur bearers are still utilized, i.e., mink, marten, otter, and beaver. Wolves are fairly abundant in some areas, and their management has become a controversial issue in some cases.

The Sitka black-tailed deer is still the major big-game species sought for recreation and food; but mountain goats, black and brown bear, and moose provide trophies and meat to nonresident as well as resident hunters.

Seals, sea lions, porpoises, and some species of whales are common to the waters of southeast Alaska. Until quite recently, seals were harvested both for hides and for bounties. The market demand for sealskins is presently rather low, and the bounty has recently been removed, so the seals (which were greatly reduced in numbers in recent years) should receive a rest from man's exploitation.

Waterfowl are abundant throughout the area, particularly during the periods of migration between northern nesting and southern wintering areas. Hunters enjoy fine shooting in many bays and tidal flats.

Blue grouse and ptarmigan furnish sport and "pot meat" throughout the fall and winter months.

Besides a rich and diversified sea bird population, southeast Alaska enjoys an abundance of bald eagles, a symbol of the wildness of the area.

In summary then, the fish and wildlife resources of southeast Alaska have gone through four distinct phases of utilization (Federal Field Committee 1968): (1) the aboriginal phase--oriented primarily toward marine resources, easily harvested, with negligible drain on productivity; (2) the exploration and colonization phase--the heavy hunting of sea otter, to the point of extinction in southeast Alaska; (3) the commercial fishery phase--from 1878 when the first salmon canneries were built to the dramatic exploitation and depletion of the salmon resource; and (4) the recent developmental phase--hunting and fishing for recreational interests have become very important, although commercial fishing and subsistence hunting still continue.

Southeastern Alaska still supports many valuable fish and wildlife resources, but conservation measures are increasingly important.

WATER

Its abundance in several forms shows that water is a dominant environmental factor in southeast Alaska. Precipitation is heavy to supply much runoff in streams of all sizes. This streamflow is the freshwater habitat for a valuable commercial and recreational fishery. The habitat productivity is due in considerable measure to favorable temperatures that result from the preponderance of cloudy weather and cool air temperatures.

Moisture is rarely a limiting factor for plant growth--the western hemlock-Sitka spruce forests are often referred to as "rain forests," and forest management is free of "dry site" problems. Muskegs, interspersed in the rain forest at lower and midelevations, are a common feature of the landscape from sea level to ridgetops.

Glaciers and icefields are prominent along the mainland. Erosion by water and ice has sculptured a rugged mountain scene of unrivaled beauty.

Drainage of the mainland heads mostly in the glaciers and snowfields of the Coast and St. Elias Mountains. It is generally westward except at the northern end of the region where drainage is also southward to Lynn Canal and Glacier Bay. The Alsek, Taku, and Stikine Rivers receive a considerable part of their flow from glaciers and the west slope drainage of the St. Elias and Coast Mountains, but they arise in the plateaus of British Columbia. The Chilkat, Skagway, Speel, Whiting, Unuk, Chickamin, and Salmon Rivers also rise in the snowfields and glaciers of the mountain ranges and their extreme headwaters reach into Canada. The drainage slopes of the mainland are steep, rocky, and deeply incised by glaciation so that there are many small drainage basins adjacent to the tidal inlets and bays that indent the coastline. Some of these smaller streams have glaciers at their headwaters, and many have lakes along their courses.

The islands of the Alexander Archipelago drain mainly to the east and west directly into tidal waters. The westerly slopes draining toward the ocean are more gradual than the drainage slopes toward the mainland so that generally the streams flowing westward are longer.

The largest stream on the islands is Hasselborg River with a drainage area of 107 square miles on Admiralty Island. It heads in lakes at an elevation of 247 feet, flows westward 6 miles, and empties into Mitchell Bay. Other large streams are the Medvetcha and Maksoutof Rivers, both of which drain westward on Baranof Island.

Runoff from lower elevation basins is about 60-100 inches annually; from intermediate to higher elevation basins of the islands and mainland, the runoff is roughly 150-200 inches.

The extreme runoff in the year 1970 was 396 inches from Sashin Creek, near Little Port Walter on Baranof Island, where the sea level precipitation was 265 inches for the period. This is an example of the common southeast Alaska situation in which basin runoff exceeds sea level precipitation. Elevation-precipitation relationships should significantly affect runoff. However, techniques for estimating runoff are of limited reliability because precipitation patterns and relationships are poorly understood (Childers 1970, p. 36).

Glaciers are a unique form of the water resource, and one that is highly significant along the mainland. Glaciers and icefields occupy about 2,200 square miles of the highlands (Field 1958).

Glaciers regulate streamflow. Runoffs from glacier-free basins in the Juneau area peak at about 13 and 14 percent of the year's runoff in May and June in response to snowmelt and again at approximately 14 percent in September due to rain. Summer flows are quite uniform, with about 12-percent level of runoff maintained for July, August, and October.

Streamflows from streams with glacier systems in their basins in the Juneau area peak at about 23 and 24 percent of the water year runoff in July and August, primarily in response to snow and ice melting. Snowmelt also contributes to the 15-percent runoff in June; rain probably is a factor in the 20-percent runoff amount for September. The higher elevations and consequent lower temperatures of glacierized watersheds cause a rapid drop in runoff beginning in October and a low base flow in December through April. The low flow probably is also related to the bare rock and coarse mantle materials common at the upper elevations.

Water parameters of particular interest in southeast Alaska are stream temperature, sedimentation, and streambed stability. Their importance is mainly as the freshwater habitat for fish. Excessive water temperatures, or even a change in the temperature regime, can affect not only fish survival but also food production and the timing of migrations of young fish to the sea. Sediment may enter stream gravels and affect fish egg and fry development by reducing intragravel water flow which results in low dissolved oxygen levels and high concentrations of metabolic wastes. Streambed stability is an important factor since bedload movement at high streamflows can destroy eggs and fry.

Stream temperatures vary throughout southeast Alaska but are generally lower than temperatures of streams at lower latitudes. This reflects the preponderance of the overcast skies and cool air temperatures characteristic of southeast Alaska's maritime climate.

Besides "glacial flour" in streams heading in glaciers, large amounts of sediment result from mass wastage and other valley and slope development processes, especially bank cutting. Slope disturbance incident to road construction is a major manmade sediment source.

Most, but not all, streambeds are unstable whether they are the short, steep watercourses of the mainland or the lower gradient streams of the islands. This is a consequence of the high streamflow response to rainstorms. The depth of such instability and the movement of streambed gravels depends on gravel size and type and stream energy.

RECREATION AND ESTHETICS

The dramatic increase in recreational and esthetic uses of the southeast Alaska outdoors demonstrates their growing importance. As a factor in the southeast Alaska resources setting they can be emphasized by reiterating a part of the most recent Alaska Outdoor Recreation Plan (State of Alaska 1970):

> Few places in the Western world offer the richness and variety of outdoor recreation resources available in Alaska.... Thus, Alaska has important assets to preserve and, unlike many other parts of the world, the opportunity to do so and to extend the recreational benefits of its natural resources to growing numbers of both residents and visitors.
>
> Rarely is a nation afforded a second opportunity to plan for the recreational use of its natural resources before commercial exploitation imposes severe constraints. Alaska, however, provides such an opportunity, and perhaps this nation's last chance to prove that compatible development of natural resources for both recreational and commercial purposes is possible.... Alaska is in a strong position to provide the nation and the world with a place of repose, away from the hurry and pressure of life in the cities, where one may enjoy the splendor of some of the world's most spectacular scenery, and view wildlife in its natural habitat.

This is interpreted here as a strong plea to recognize the long-term importance of the natural scenic landscape before its values are depleted by industrial ventures, most of which are ephemeral in comparison. The recreation resource is expected to emerge as Alaska's greatest asset.

What is said about the recreation resource of the State as a whole is applicable to an even greater extent in southeast Alaska where some unique scenic and recreational resources are found.

Land management must respond to changing needs manifest in the shifting patterns of public demand on forests and related resources.

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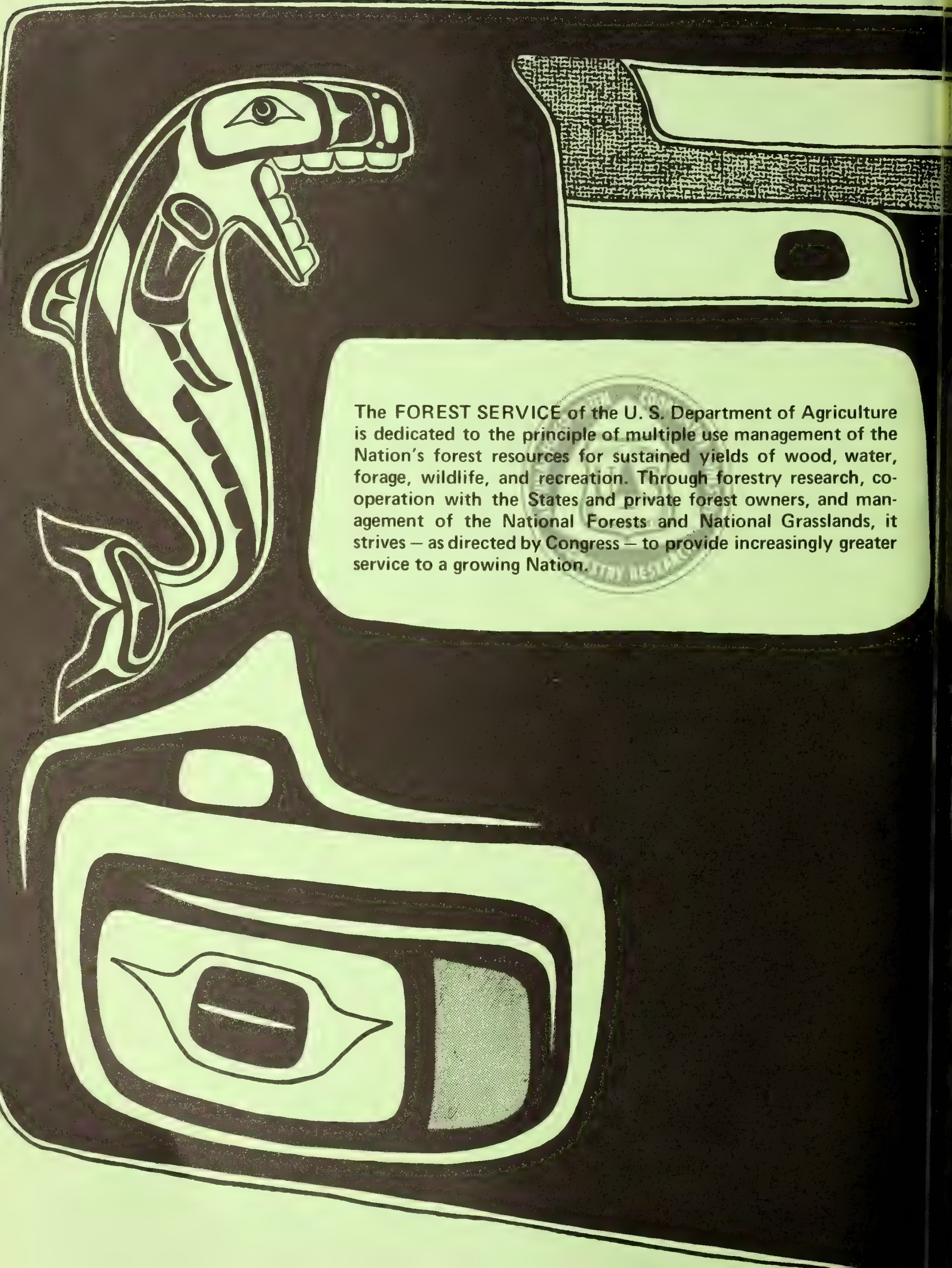

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USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW-13

THE FOREST ECOSYSTEM OF SOUTHEAST ALASKA

2. Forest Insects

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ABSTRACT

Southeast Alaska's remaining virgin forests have few insect pests. The black-headed budworm and the hemlock sawfly, both western hemlock defoliators, are the most important species. They kill some trees, kill tops in others, and cause growth loss, but stands survive their attacks. Extensive conversion of virgin stands to second growth may result in an increase in pest problems as it has in similar areas such as coastal British Columbia. Widespread use of insecticides to control major outbreaks is not practical because of risk of contaminating salmon-spawning and trout-rearing streams; but insecticide use may be justified in local, high value areas. Weather, diseases, and parasites control outbreaks naturally. Damage-prone stands should be identified and harvested before insect attack or salvage-logged following outbreaks. Ideally, second-growth stands should be managed for resistance to insect pests.

Keywords: Insects, natural control (insects), southeast Alaska, research.

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PREFACE

This is the second in a series of publications summarizing knowledge about the forest resources of southeast Alaska.

Our intent in presenting the information in these publications is to provide managers and users of southeast Alaska's forest resources with the most complete information available for estimating the consequences of various management alternatives.

In this series of papers, we will summarize published and unpublished reports and data as well as the observations of resource scientists and managers developed over years of experience in southeast Alaska. These compilations will be valuable in planning future research on forest management in southeast Alaska. The extensive lists of references will serve as a bibliography on forest resources and their utilization for this part of the United States.

Previous publications in this series include:

1. The Setting.

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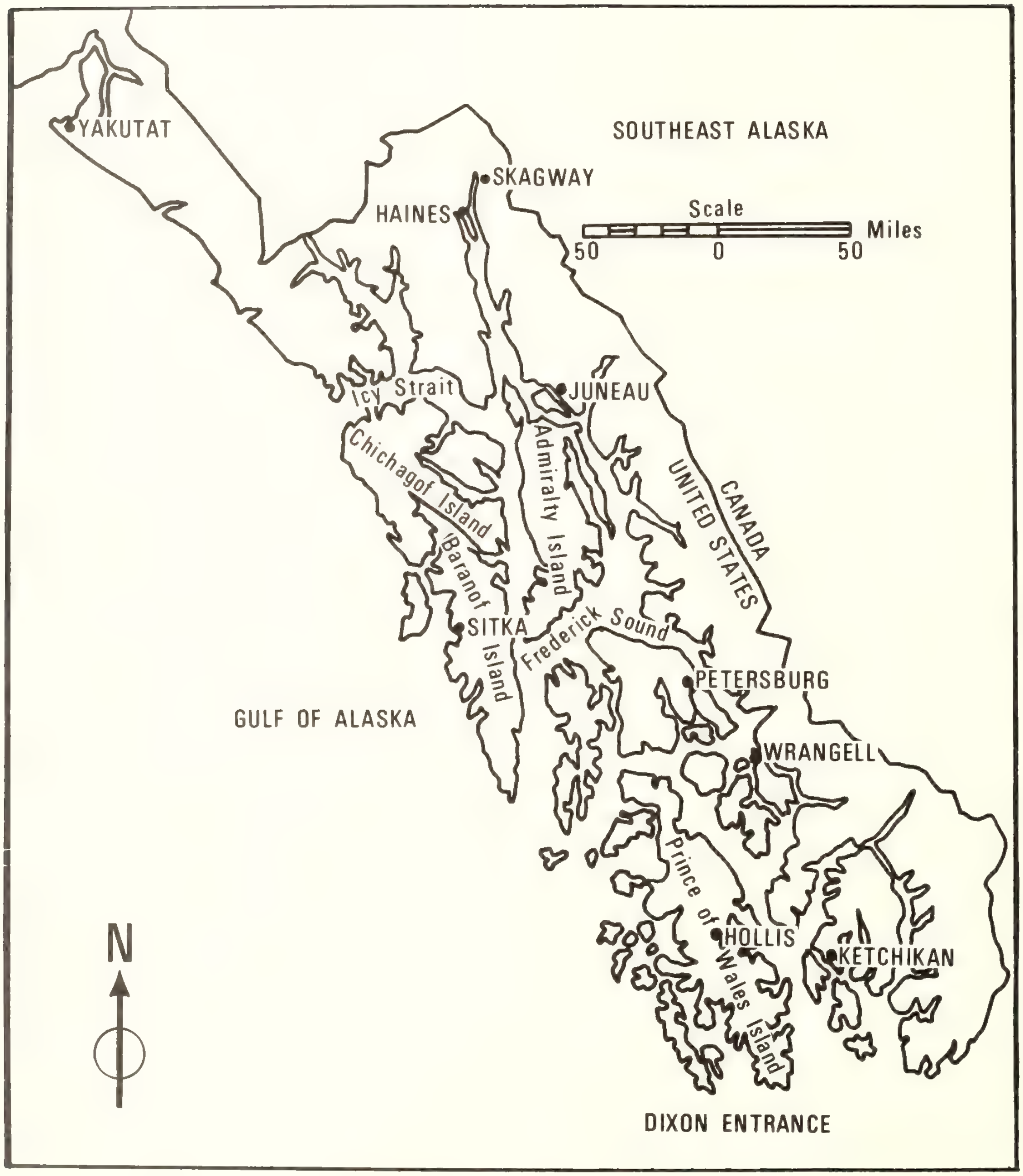

Figure 1.--Map of southeast Alaska east of the 141st meridian.

The harsh reality of the situation is that we must live with pests--be they insects, mites, snails, worms, fungi, bacteria, viruses, epiphytic plants, allergens, or weeds. Rarely do we eradicate them; the best we can do is to coexist with them. We and they are part of a giant ecosystem, and man is merely trying to shift the balance of power so he can exist in reasonable comfort and security. It is necessary for us to be sufficiently objective to understand this ecosystem in which the role of man is defined as a competitive force, albeit a bit more intellectual and far-sighted than his competitors. (McNew 1972, p. 119.)

INTRODUCTION

The resource manager concerned with forest protection must examine southeast Alaska (fig. 1) in the light of its unique character. Compared with coniferous forests at lower latitudes, biotic diversity is limited for several reasons. Geologically, this region has only recently been freed from glaciation and has a maritime climate with relatively mild winters and cool, moist summers. It is separated from the rest of the North American Continent on the north and east by a range of continually snowclad coastal mountains which acts as a climatic and physical barrier to reinvasion of flora and fauna. Beyond the coastal range, life is adapted to a continental climate with extremely long, cold winters and hot, dry summers. Therefore, the main avenue for reinvasion by plant and animal species adapted to a maritime climate is from coastal British Columbia immediately to the southeast.

The climate of southeast Alaska is more rigorous, however, than that of coastal British Columbia, and there are indications that weather during the growing season may be a limiting factor in the growth and distribution of some species (Andersen 1955). For example, climate apparently limits the northward distribution of western redcedar, *Thuja plicata* Donn (Andersen 1953), which occurs naturally only in the southern half of southeast Alaska. Pacific silver fir, *Abies amabilis* (Dougl.) Forbes, Pacific yew, *Taxus brevifolia* Nutt., swordfern, *Polystichum munitum* (Kaulf.) Presl, and salal, *Gaultheria shallon* Pursh, all reach the northern extremities of their ranges in southern southeast Alaska (Hultén 1968). Mean site index, a ratio of tree height over age which diminishes from south to north in southeast Alaska (Andersen 1953), is apparently related to temperature during the growing season.

The hemlock sawfly, *Neodiprion tsugae* Midd., has not been positively identified north of southeast Alaska, although its primary host, western hemlock, *Tsuga heterophylla* Raf. (Sarg.), occurs as far north as the Kenai Peninsula. The Sitka spruce weevil, *Pissodes sitchensis* Hopk., a major pest of Sitka spruce, *Picea sitchensis* (Bong.) Carr., in the Pacific Northwest and British Columbia has not been found north of coastal British Columbia (Wright 1970), although its host occurs around the Gulf of Alaska to Kodiak Island. The black-headed budworm, *Acleris gloverana* (Wals.), formerly referred to as *A. variana* (Fern.) (Powell 1962), becomes epidemic sporadically in southeast Alaska (Schmiege and Crosby 1970), and the acreage of defoliated forest varies directly with regional temperature during the adult and larval periods.[1/] The western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst.), found only in the southern part of southeast Alaska, occurs primarily south of 56 degrees latitude in British Columbia (Jardine 1969). This may be due to the distribution of its primary host, western hemlock, in British Columbia (Fowells 1965).

Fewer species of insects are considered pests on southeast Alaska's trees (Hard 1967) than those considered pests on the same tree species farther south (Keen 1952). Also, the major insect species that occur in southeast Alaska in addition to forests farther south are parasitized by fewer insect species in Alaska (Torgersen 1968, 1970). The known parasite fauna of southeast Alaska is composed primarily of hymenopterous species. Few parasitic dipterous species are represented, although flies that breed in aquatic habitats are abundant.

In the relatively simple Alaskan ecosystem, such species as the black-headed budworm often become more widespread when released by periods of favorable weather than they do in the conterminous Pacific Northwest States. This is probably due in part to the scarcity of regulatory feedback loops between tree species, pest species, and parasite and predator species that interact to govern the stability of the system. Simple ecosystems, those having relatively few species of flora and fauna with few energy pathways leading from the primary producers to the ultimate consumers, are usually unstable ecosystems (Odum 1959, Wilson and Bossert 1971). In contrast, diverse systems are more stable, and serious pest outbreaks occur infrequently (Southwood 1972).

There are no records of forest insect outbreaks in southeast Alaska before 1917. Since that time a number of epidemics have been documented, but insect control measures have never been taken for economic reasons. Within much of the remaining virgin forests, insect damage may continue to

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[1/] John S. Hard. Black-headed budworm (Lepidoptera: Tortricidae) population fluctuations in coastal Alaska in relation to temperature during adult and larval periods. Unpublished report, Forestry Sciences Laboratory, Juneau, Alaska, 1972.

fall within the limits of acceptable loss. A more complete understanding of the virgin forest ecosystem may show that the "pest" insect species are actually beneficial, since virgin forests have been evolving for thousands of years with insects an integral part.

Some effects of feeding by insects are opening of the forest canopy to allow greater light penetration to understory vegetation, alteration of species composition of both woody and herbaceous plants, and changes in the composition of litter. These and many other effects of insect feeding may result in greater total forest productivity through increased nutrient availability (Rafes 1970).

As more virgin forest is converted to intensively managed second-growth forest, insect damage may reach economically unacceptable levels because of increased competition between insects and man and because insects innocuous in virgin forests may suddenly become pests in altered forest habitats as they have in British Columbia (Silver 1962) and other areas.

> *Actually, pest status appears to originate in four ways: by the entry of species into previously uncolonized regions; by changes in the characteristics of species that did not previously compete or otherwise interact directly with man; by changes in man's activities or habits, which make him sensitive to the existence of species to which he was previously indifferent; and by increases in the abundance of species whose interactions with man were previously negligible because of the low numbers in which they occurred. Such increases happen for one of three reasons, i.e. a lasting increase in the supply of a limiting resource, a lasting decrease in the frequency or severity of repressive interactions that previously prevented the species from exploiting fully the resources of their environments, and the simultaneous occurrence of both of these changes.* (Clark et al. 1967, p. 183.)

Insect suppression may become necessary in second-growth forests because logging will convert large areas of relatively unstable all-aged virgin forests to even less diverse, more unstable even-aged forests (Mitchell 1970).

> *The complex ecosystems of natural areas are generally more stable than ecosystems that have been drastically altered by man, since the latter may achieve stability only at the cost of large energy supplements.* (Moir 1972.)

Essentially, then, the conversion of Alaska's virgin forests to managed forests appears to be a step toward greater instability and a resultant increase in insect-caused damage, as has happened elsewhere (Graham 1956). Therefore, the relationships between insect and tree populations must be understood in order to develop biologically and economically sound forest management practices. The following biological information on major forest insect species, although incomplete, contributes to an understanding of the insect-tree relationship.

MAJOR SPECIES

BLACK-HEADED BUDWORM

The most important insect species in southeast Alaska forests is the black-headed budworm. This species prefers hemlock but defoliates spruce also. Phenology of the budworm is more closely synchronized with western hemlock than with Sitka spruce, whose buds burst earlier than hemlock, suggesting greater survival of young larvae on hemlock (Schmiege and Hard 1966b), since young larvae typically feed singly within the buds (Werner 1969). In addition, the budworm prefers hemlock for oviposition (Schmiege and Hard 1966b). Although the budworm concentrates its feeding on hemlock buds and current year's needles, egg production of females appears to be unaffected if nearly mature larvae are forced to complete development on previous years' needles (Schmiege 1965).

The budworm is also a major pest in the nearby coastal forests of British Columbia where damage to second-growth hemlock is of special concern (Prebble and Graham 1945a, Fiddick 1972). Frequently, a succession of budworm outbreaks begins in the Olympic Peninsula or southern British Columbia and progresses north to the Queen Charlotte Islands, southeast Alaska, and Prince William Sound[2/] (Prebble and Graham 1945a; Downing 1957, 1961). This phenomenon could be interpreted as the result of dispersal by moths from heavily defoliated stands since they have strong flight capabilities.[3/] Also, fall storms that occur during the budworm's flight period in September often come from the southeast which could partially account for the progression of outbreaks up the coast.

[2/] H. B. Leech. The hemlock tip-moth (*Peronea variana* Fernald) in British Columbia. B.S. thesis, University of British Columbia, Vancouver, 70 p., illus., 1933.

[3/] W. F. McCambridge. The black-headed budworm survey on the Tongass National Forest, Alaska, season of 1952. Unpublished report, USDA Bureau of Entomology and Plant Quarantine, Portland, Oreg., 11 p., illus., 1952.

A more likely explanation is that there are resident low-level populations capable of building up in place throughout southeast Alaska and in the forests of Prince William Sound to the north. Another possible explanation is that budworm populations throughout coastal British Columbia and southeast Alaska begin to increase simultaneously; but populations in the northern part of the region require more time to reach epidemic proportions because of the characteristically cooler temperatures there. Analysis of budworm populations in eastern Canada revealed a direct relationship between population trend and sum of degree-days (Miller 1966). Budworm population trends in coastal British Columbia and Alaska also are related to weather (Silver 1960, 1963; Schmiege 1966b), and rate of budworm development in Alaska is related to cumulative temperature.[4/][5/]

The earliest recorded defoliator outbreak in Alaska tentatively attributed to the budworm occurred between 1917 and 1921 (Downing 1957). The second outbreak, which resulted in some defoliation on nearly every forested acre in southeast Alaska, with greatest defoliation on well-drained slopes and in second-growth hemlock, occurred between 1948 and 1955 (McCambridge 1956). As a result of this outbreak appraisals of damage were made in three separate areas.

The first appraisal was made from the air on selected areas in the southern half of southeast Alaska in 1953,[6/] the peak year of the outbreak. Most damaged areas occurred on north- and east-facing slopes at elevations between 450 and 900 feet (see footnote 4). Only hemlock stands that contained 50 percent or more of their stems with some degree of top kill were mapped. A gross volume of 105 million board feet of hemlock on 6,600 acres had 50 percent or more dead crown length. The area with less than 50 percent dead crown length covered nearly 12,000 acres and contained a total hemlock volume of 180 million board feet. This report was a conservative appraisal because mortality as a result of heavy defoliation is often delayed (Kinghorn 1954), and weakened trees may deteriorate further from fungus infection (Johnson et al. 1970).

4/ W. F. McCambridge. Studies of the biology and control of the black-headed budworm in Alaska. Progress Report, Alaska Forest Research Center, Juneau, Alaska, 11 p., illus., 1955.

5/ William E. Rose. The development of the black-headed budworm, *Acleris variana* (Fernald) in response to environmental factors. M.S. thesis, University of Massachusetts, Amherst, 51 p., illus., 1962.

6/ F. T. Hutchison. An aerial appraisal of black-headed budworm damage on selected areas of the Tongass National Forest. Special report, Forest Insect Laboratory, Portland, Oreg., 8 p., illus., 1953.

The second appraisal[7] was made of mature stands on Admiralty Island in 1956, the year following collapse of the budworm outbreak in Alaska. The stands in this area were severely damaged by repeated defoliation. The appraisal showed that net volume loss averaged 7,300 board feet per acre and that the budworm showed no preference for either overstory or understory trees. An earlier examination (see footnote 4) of 121 budworm-damaged areas in the Admiralty Lakes area showed that they were most numerous at elevations between 450 and 900 feet and on north- and west-facing slopes. Also, the damaged areas were confined to mature stands containing over 50 percent western hemlock by volume.

A third appraisal (McCambridge 1956) was made near Juneau of second-growth hemlock and spruce stands that had experienced a single year of heavy defoliation. The hemlock stand, which was densely stocked, had top-kill in 25 percent of all hemlock trees, but top-kill in 85 percent of the dominant crown class trees and 52 percent of the codominant crown class trees. The spruce stand, which was much less densely stocked, had top-kill in 74 percent of all spruce trees, but top-kill in 93 percent of the dominant crown class trees and 86 percent of the codominant crown class trees. However, the top-kill in spruce was confined primarily to current year's shoot growth, whereas in hemlock top-kill extended into previous years' shoot growth.

The most recent occurrence of significant budworm defoliation in southeast Alaska occurred between 1962 and 1964 (Crosby 1965), but the outbreak collapsed in 1965 (Crosby 1966). Since then, budworm populations have remained at endemic levels and no damage has been reported. However, budworm populations reached outbreak status in 1970 on the Olympic Peninsula of Washington (Pettinger and Dolph 1971) and on Vancouver Island in British Columbia (Wood and Koot 1972) and are increasing in the Prince Rupert District of British Columbia (Andrews and Erickson 1972, Fiddick 1972). A sharp increase in budworm populations in Alaska can be expected soon. Samples taken of budworm larvae in 1971 and budworm eggs and larvae in 1972 and 1973 show that budworm populations are already increasing in southeast Alaska near Ketchikan.

HEMLOCK SAWFLY

The second most important forest insect in southeast Alaska is the hemlock sawfly (Middleton 1933, Hard and Schmiege 1968, Schmiege 1970). Its primary host is western hemlock, but other conifer species may be fed upon if they are overtopped by defoliated hemlock. Damage is often

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[7] G. L. Downing. Western hemlock damage caused by the black-headed budworm, appraisal survey Thayer Lake, Admiralty Island, Alaska. Unpublished report, USDA Forest Service, Alaska Forest Research Center, 7 p., 1957.

greatest in large hemlocks of all-aged stands.[8/] Unlike the budworm, this species feeds primarily on previous years' needles, and the larvae feed in clusters. Nearly mature larvae forced to complete development in the laboratory on an unnatural diet of current year's needles experienced a disproportionate increase in female mortality and reduced egg production in survivors (Hard 1971a). In the field, heavily defoliated hemlock trees produce less fecund and proportionately fewer females than do lightly defoliated trees, indicating a feedback mechanism between host and insect that keeps the sawfly from reaching the damaging proportions characteristic of the black-headed budworm. A study of the sawfly in British Columbia showed a similar relationship between population density, sex ratio, and egg production.[9/]

Hemlock stands in British Columbia that appeared most prone to sawfly outbreaks had a heavy undergrowth of salal (see footnote 9). This broad-leaved evergreen species occurs in Alaska as far north as Sitka (Hultén 1968, Viereck and Little 1972) and is abundant on Prince of Wales Island. The sawfly has been more active in southern southeast Alaska than in the northern half, and local outbreaks persist longer in the south. Areas on Prince of Wales Island that have a history of repeated sawfly outbreaks often have salal as a major component of the ground vegetation. In addition, a study of the abundance of sawflies by stand composition and site index in British Columbia showed that sawflies were most abundant on the intermediate sites of an open stand containing 60 percent western hemlock and 40 percent western redcedar, which resembles some infested stands in Alaska. The areas in British Columbia with the next most abundant sawfly populations were on the intermediate sites of a closed, pure hemlock stand with salal and swordfern as the most abundant ground cover species (see footnote 9).

The sawfly often becomes epidemic in the same areas and at the same time as the budworm, which suggests that populations of both species may be released by a common environmental factor (Downing 1961). When both species feed together on the same tree, which often happens, the tree may be completely defoliated (Schmiege 1970). Competition for food between the species is probably more detrimental to the sawfly for several reasons. Sawflies hatch later than budworms, become established later, and complete development later. In case of a local food shortage within a tree or between adjacent trees, sawfly larvae must walk to a more favorable feeding site, whereas budworm larvae can spin webs and drop to a more favorable feeding site. The budworm apparently can complete development on previous years' needles, but the sawfly cannot complete development on current

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[8/] R. F. Taylor. Insect infestation, report for field season of 1932. Unpublished report, USDA Forest Service, Juneau, Alaska, 11 p., illus., 1932.

[9/] George Stuart Brown. Some factors influencing the populations of the hemlock sawfly, *Neodiprion tsugae* Midd. M.S. thesis, University of British Columbia, Vancouver, 57 p., illus., 1951.

year's needles without detrimental effects. Also, sawfly adults in Alaskan populations do not appear to have the strong flight capabilities of the budworm which enables budworm moths to disperse readily from defoliated to undefoliated areas. This could be due to colder temperatures during the adult sawfly period, since peak emergence usually occurs in early October.

Additional differences between the sawfly and the budworm may account for the latter's reputation as the more destructive species. Females in a healthy sawfly population have a mean fecundity of 72 eggs (Hopping and Leech 1936, Hard and Schmiege 1968), but females in a healthy budworm population have a mean fecundity of at least 87 eggs (Schmiege 1965). In the laboratory, a single sawfly larva consumes approximately 80 hemlock needles (Hard and Schmiege 1968), but a single budworm larva destroys approximately two buds, each capable of producing over 50 needles, and consumes or destroys an additional 60 needles (Werner 1969).

Another major difference between the two species is that during outbreaks sawfly infestations occurred commonly in local areas on south to northwest aspects (see footnote 8) (Hard 1971b), but budworm damage was much more widespread and occurred commonly on west, north, and east aspects (see footnote 4). Whether this is an inherent difference between the two species or whether other factors such as climate in southeast Alaska are more favorable to buildup of budworm populations is unknown. When all of the known differences between the sawfly and the budworm are considered, it appears that the sawfly is more closely in harmony with its primary host, western hemlock, than is the budworm.

OTHER DEFOLIATORS OF POTENTIAL IMPORTANCE

Four additional moth species of potential importance to southeast Alaska's forests are a spruce budworm, *Choristoneura* sp., probably *orae* Free. but formerly referred to as *fumiferana* (Clem.) (Freeman 1967), the western hemlock looper, *L. fiscellaria lugubrosa*, the saddleback looper, *Ectropis crepuscularia* Schiff., and the green-striped forest looper, *Melanolophia imitata* Wlk.

A small spruce budworm outbreak occurred on Sitka spruce near Haines between 1948 and 1950 but apparently resulted in no permanent damage (Downing 1957). No other outbreak of this species in southeast Alaska has been recorded.

In 1965 and 1966 a local hemlock looper outbreak occurred about 50 miles southeast of Wrangell.[10] Approximately 400 acres of vigorous Sitka spruce were heavily defoliated (Torgersen and Baker 1967). This is the only outbreak of the hemlock looper ever recorded in Alaska, but the looper is very destructive in coastal forests of British Columbia and the Pacific Northwest (Keen 1952) where outbreaks have occurred repeatedly, particularly on mature, open-grown hemlock in valley bottoms (Kinghorn 1954, Jardine 1969).

Both the saddleback looper and the green-striped forest looper occur commonly in southeast Alaska; but to date, only the saddleback looper has reached outbreak status. It, with the hemlock sawfly, caused moderate to severe defoliation and some mortality of western hemlock on 200 acres near Ketchikan in 1969 (Crosby and Curtis 1971). Both loopers attack a wide range of tree and shrub species (Sugden 1964), but western hemlock is a preferred host.

The saddleback looper caused heavy tree mortality on over 10,000 acres of forest near Kitimat, British Columbia, in 1960 and 1961 (Ruth and Silver 1966) but had not been considered a serious pest before this (Morris 1970).

The green-striped forest looper was not regarded as a serious forest pest either until 1960, when it defoliated approximately 23,000 acres of forest on the west coast of Vancouver Island (Silver et al. 1962). In 1963 and 1964 an outbreak extended over 100,000 acres on Graham Island in the Queen Charlotte Islands of British Columbia, but the population declined apparently due to unfavorable weather during the larval period in 1964 (Fiddick et al. 1965).

The spruce aphid, *Neomyzaphis abietina* (Wlkr.), is a sapsucking insect whose feeding defoliates and often kills Sitka spruce in the Pacific Northwest (Keen 1952) and coastal British Columbia (Holms and Ruth 1968). This species caused some Sitka spruce mortality near Sitka in 1969 and 1970, but the outbreak has subsided.

The spruce aphid can reproduce throughout the year, so a mild winter may release aphid populations and a harsh winter may aid in causing a population to collapse (Wilson 1948, Bevan 1966, Holms and Ruth 1968, Parry 1969). In British Columbia this species is considered a pest of ornamental trees and nurseries. In Alaska it may become a pest in local areas if released by favorable winter weather, but natural control factors such as parasites, starvation (Hussey 1952), and harsh winter weather can be expected to bring aphid populations under control before widespread damage occurs.

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[10] J. W. Quimby. The use of frass drop in predicting defoliation caused by the western hemlock looper (*Lambdina fiscellaria lugubrosa* (Hulst)) in southeast Alaska. M.F. thesis, University of Michigan, Ann Arbor, 52 p., illus., 1967.

Occasionally, hardwoods are defoliated by the cottonwood leaf beetle, *Chrysomela scripta* F. In 1971 and 1972 the striped alder sawfly, *Hemichroa crocea* (Fourcroy), infested young alder stands near Juneau. Elsewhere both species produce more than one generation per year (Baker 1972) but appear to produce only one in southeast Alaska. Hardwood species can survive repeated defoliation; therefore mortality due to these species is negligible, but growth is reduced.

SPRUCE BEETLE

The most important bark beetle in terms of reported damage in southeast Alaska is the spruce beetle, *Dendroctonus rufipennis* Kby., formerly called *Dendroctonus obesus* (Mann.). This species is a major pest of spruce in coastal Oregon and Washington (Keen 1952) and the most destructive pest of spruce in British Columbia (Grant and Cottrell 1968, Collis and Harris 1970).

Between 1941 and 1946, this species killed over 35 million board feet of Sitka spruce on a 6,400-acre tract on the west side of Kosciusko Island.[11/] This particular stand was one of the last of high-quality, mature Sitka spruce in southeast Alaska. The infested area was on humpy terrain with shallow, well-drained soil over limestone. The stand was composed of approximately two-thirds spruce and one-third hemlock, with much of the spruce over 400 years in age and 4 feet in diameter. This overmature stand was ripe for attack by the spruce beetle, and a number of additional factors could have contributed to the outbreak. Extensive windthrow occurred on the west side of Kosciusko Island before the outbreak, and during World War II logging took place at Edna Bay within 5 miles of the outbreak area. It is possible that beetles multiplied in down timber or slash and moved to the live trees. Another possibility is that weather conditions became favorable for beetle population increase, since rate of brood development increases with temperature (Collis and Harris 1970). Weather records for the immediate area are not available, but an examination of weather data for Sitka, approximately 100 miles northwest, revealed that the summers of 1939-42 were warmer than normal and those of 1939-41, drier than normal. Since both areas occur on the west coast of southeast Alaska where climate is relatively uniform, it is reasonable to assume that conditions probably were similar and that weather released the beetle population.

[11/] R. L. Furniss and Ivan H. Jones. A second report concerning the bark beetle outbreak on Kosciusko Island. Unpublished report, USDA Forest Service, Portland, Oreg., 9 p., illus., 1946.

In 1956 an appraisal was made of a much smaller spruce beetle outbreak confined to a north-facing slope where western hemlock predominated on Dall Island.[12/] Approximately 1-1/2 million board feet of mature Sitka spruce died on 200 acres over several years, but the outbreak apparently subsided in 1957 (Downing 1957).

Stands in southeast Alaska where mature Sitka spruce occurs as a major component are often confined to primary succession zones such as along rivers and beaches. The most extensive mature spruce stands occur near Yakutat. However, there remain no extensive overmature stands comparable to the one that was decimated by the spruce beetle on Kosciusko Island. Susceptibility of existing spruce stands to attack by the spruce beetle probably depends on weather conditions favorable to the beetle, availability of spruce slash or blowdown in a condition suitable for beetle brood production, or stands of low vigor trees weakened by flooding, defoliation, or prolonged drought.

CEDAR BARK BEETLE

A cedar bark beetle, *Phloeosinus squamosus* Blkm., infests both western redcedar and Alaska-cedar, *Chamaecyparis nootkatensis* (D. Don) Spach., in southeast Alaska. Downing (1960) surveyed a cedar bark beetle outbreak extending over several thousand acres of scrub cedar on Kuiu and Kupreanof Islands and killing thousands of cedar trees in the larger diameter classes.

Because cedar is rot resistant, many of the beetle-killed trees are still standing, and large areas of whitened cedar snags are visible from the air. Causes of this outbreak are unknown, and since cedar has until only recently been considered of limited value, compared with hemlock and spruce, no attempt has been made to study the cedar-beetle relationship.

Much of the dead cedar throughout southeast Alaska occupies poorly drained slopes and muskegs and may have died from a variety of causes over a prolonged period. The durability of cedar wood accounts for a seemingly larger amount of mortality compared with that of hemlock and spruce. Since the latter two species deteriorate rapidly after death, aerial observation reveals recent mortality, whereas observation of dead cedar reveals cumulative mortality over a much longer period.

[12/] George L. Downing. Sitka spruce beetle, South Tongass National Forest, Port Bazan, Dall Island, Alaska. Unpublished report, USDA Forest Service, Alaska Forest Research Center, 2 p., 1956.

AMBROSIA BEETLE

The ambrosia beetle, *Trypodendron lineatum* (Oliv.), is not destructive to living trees, but its reproductive behavior damages softwood logs. Adults bore into logs during late spring and early summer, lay eggs, and inoculate the mines with a symbiotic fungus which serves as larval food. Damage is not structural because the mines are very small in diameter. However, the introduced fungus causes a blue-to-black staining of wood cells surrounding the mines, decreasing log value, especially if it is to be converted to lumber or veneer (McBride 1950, McBride and Kinghorn 1960). Fortunately, most of the damage is confined to sapwood, but it may extend into the heartwood depending on tree species (Prebble and Graham 1957).

Ambrosia beetle damage cannot be eliminated economically because beetle populations breed in stumps, slash, and fallen trees; but it can be reduced substantially by maximum utilization of breeding material to reduce population buildup and through log handling practices. Logs from trees felled between late summer and midwinter are much more attractive to ambrosia beetles than those from trees felled between late winter and midsummer (Dyer and Chapman 1965). Therefore, if logs from autumn-felled trees are stored in water before the beetle attack period, which occurs normally in June, damage will be reduced. The exposed portions of floating logs may be damaged (Richmond and Radcliffe 1961), but there is little chance for population buildup in log rafts because brood survival is low in water-soaked logs (Dyer and Chapman 1962). However, salt water log storage creates a marine borer hazard (see section on shipworm). If logs are stored on land at the log dump or mill, damage by ambrosia beetles can be reduced substantially by keeping the logs soaked with a continuous fine water mist (Richmond and Nijholt 1972). Sprinkling also reduces log deterioration caused by checking and fungi (Lane and Scheffer 1960, Roff and Dobie 1968).

OTHER BEETLES OF POTENTIAL IMPORTANCE

The Sitka spruce weevil, mentioned earlier, is a potential pest of spruce in southeast Alaska. This insect kills the leaders of young spruce, which results in reduced height growth, a deformed stem, and poorer log grade of the host tree (Wright 1970). It occurs in coastal British Columbia, but has not been found in the Queen Charlotte Islands. Although adults in Washington are active and feed on host stems and laterals in winter, temperatures in the Queen Charlotte Islands and southeast Alaska may be too low to permit establishment of the weevil. The lower host stem temperature threshold for weevil mating is approximately 65° F. and for egg-laying, approximately 75° F. (Gara et al. 1971), both relatively high temperatures for southeast Alaska. On Vancouver Island (Harris et al. 1968) and in Oregon (Wright and Baisinger 1956), intensity of attack by the weevil was highest on young spruce in valley bottoms and lowest in areas close to tidewater.

Another weevil species, *Steremnius carinatus* (Boh.), that girdles and kills conifer seedlings in coastal British Columbia (Condrashoff and Kinghorn 1963), occurs in southeast Alaska. This species breeds in stumps and roots, and the adults feed on the bark of conifer seedlings and on ground vegetation (Koot 1972). Apparently the weevil has caused extensive damage only in areas in coastal British Columbia where forests were clearcut, burned, and planted within a 2- or 3-year period. Adult weevils that emerged from stumps killed many conifer seedlings, the only food available (Lejeune 1962).

In southeast Alaska, clearcut areas normally regenerate naturally and much ground vegetation is present with conifer seedlings. Thus, this weevil is unlikely to become more than a temporary and local problem.

SHIPWORM

The shipworm, *Bankia setacea* Tryon, is not an insect but a mollusk, destructive to rafted logs and untreated piling in British Columbia and Alaska. This marine borer, incorrectly called *Teredo* but closely related, is especially destructive in booming grounds and log storage areas because of population buildup in sunken logs and subsequent mining in fresh logs. Chemicals will protect logs from attack, but such treatment is a potential contamination hazard.

Shipworm damage can be eliminated or substantially reduced by (1) transporting logs by barge and storing them on land, (2) removing sunken logs from log storage areas, (3) minimizing the period when logs are stored in salt water, or (4) storing logs in fresh water since salinities of six or fewer parts per thousand are lethal to *Bankia* (Bramhall 1966). There are few bodies of fresh water suitable for log storage in Alaska, and storage at river mouths provides limited protection (Trussel et al. 1956). Perhaps fresh water impoundments deep enough for storage of floating logs could be constructed on the ocean surface. This would also protect the logs from ambrosia beetles.

NATURAL CONTROL FACTORS

Pest insect populations fluctuate from endemic levels where no noticeable damage occurs to epidemic levels where damage becomes prevalent. Little is known about the causes of epidemics, but favorable weather is apparently an important factor in the release of insect populations near the extremities of their ranges (Watt 1968). Much more is known about natural factors involved in collapses of pest epidemics: (1) parasitic insects, (2) predators such as spiders, birds, and small mammals, (3) microbial disease organisms such as viruses, fungi, and bacteria, (4) starvation, and (5) adverse weather. Parasites, predators, disease organisms, and starvation kill proportionately more insect hosts as the hosts become more abundant, whereas adverse weather usually affects insects

independent of their abundance. Near the extremities of an organism's natural range, adverse weather is usually a more important mortality factor than are biological agents (Watt 1968). Weather may also regulate the effectiveness of the biological mortality agents because parasite and predator activity and growth of pathogenic organisms are controlled by such factors as temperature and humidity.

Little is known of the effects of predation on forest insect populations in southeast Alaska. Small mammals such as mice, voles, and shrews are suspected of causing minimum pest mortality, compared with spiders and birds, except to insect species such as some loopers that pupate on the ground. Much more is known about the parasitic insects than any other pest mortality factor, but viruses and fungi appear to be the most important biological agents contributing to the collapse of forest pest epidemics in southeast Alaska.

The parasite complex of the black-headed budworm in southeast Alaska is composed of at least 16 species that attack budworm eggs, larvae, and pupae. This contrasts sharply with a total of 48 species that attack the budworm in coastal British Columbia (Torgersen 1970). Budworm populations in Alaska are also infected by an unidentified virus and a fungus, *Empusa grylli* (Fres.) Nowak.[13/] A polyhedral virus was considered to be the most important natural control factor involved in the collapse of the budworm outbreak in coastal British Columbia in the 1940's (Prebble and Graham 1945b, Graham 1954). Although associations do exist between budworm population fluctuations and weather in coastal British Columbia and southeast Alaska, the only quantitative measure of budworm mortality attributed to effects of weather was an average egg loss of 30 percent during three winters in the early 1960's (Schmiege 1966a).

The parasite complex of the hemlock sawfly in southeast Alaska is composed of at least nine species, and most of them attack prepupal sawfly larvae within cocoons (Torgersen 1968, 1969). In Oregon, the sawfly parasite complex consists of at least 20 species and most attack host larvae in cocoons (Furniss and Dowden 1941). Studies in Holland show that larval sawfly predation by birds and parasitism by wasps are low compared with attacks on moth larvae. This is apparently due to evolved sawfly behavior mechanisms whereby visual stimuli in the form of moving enemies elicit larval responses, such as rearing, stretching, jerking, or regurgitation of a droplet of fluid, which startle or repel the potential attacker. The effect is greater if several larvae or an entire feeding colony respond simultaneously (Prop 1960). Hemlock sawfly larvae respond

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13/ W. F. McCambridge. Studies of the biology, habits, and control of the black-headed budworm in Alaska, season of 1953. Unpublished report, USDA Forest Service, Pacific Northwest Forest & Range Experiment Station, Portland, Oreg., 25 p., illus., 1954.

in nearly identical ways to threat, which may partially account for the very low incidence of larval parasitism. No viruses have been isolated from Alaska sawfly populations, but apparently a virus has caused sawfly mortality in coastal British Columbia (see footnote 9).

The most important pathogen of the hemlock sawfly in Alaska is a fungus, *Entomophthora sphaerosperma* (Fres.), which infects larvae. Recent studies showed this fungus was much less prevalent in sawfly populations in 1971 than in 1969 and 1970. However, the summer of 1971 was comparatively dry, and many fungi require moist conditions for growth. In a study made in 1945, an unidentified fungus was considered to be the most effective natural control agent of the sawfly on Vancouver Island.[14/]

No attempts have been made to correlate sawfly population fluctuations with weather. The only quantitative measure of weather-induced loss was 34-percent mortality of sawfly eggs during the overwintering stage in hemlock needles in 1964-65 (Schmiege 1966a). The amount of overwintering mortality apparently varies among years according to weather conditions. The winter of 1971-72 in southeast Alaska was characterized by extremely prolonged cold weather and little rain. As a result, much of the western hemlock near Juneau showed signs of "winter burn" or moisture stress and many needles dried and fell off. Therefore, egg mortality of both budworms and sawflies may have been significantly higher than average during the winter of 1971-72 due to loss of egg-bearing needles.

An appraisal of natural mortality factors of the hemlock looper outbreak near Wrangell showed the parasite complex for the looper to consist of at least eight species (Torgersen 1971). This compares with a complex of at least 12 parasite species that attack the looper in the Pacific Northwest[15/] and British Columbia (Hopping 1934). The most important mortality factor of the looper in southeast Alaska was a polyhedral virus which caused the population to collapse during the late larval stage in 1966 (Torgersen and Baker 1967).

Hemlock looper outbreaks in British Columbia appear to be related to unusually dry weather in September, when looper moths normally mate and lay eggs[16/] (Thomson 1952). Analysis of precipitation records for Wrangell,

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[14/] G. R. Wyatt and P. H. D. Parizeau. Studies on the hemlock sawfly, *Neodiprion tsugae* Midd. at Quatsino Sound, B.C., in 1945. Report of Forest Insects Investigations, Victoria, B.C., 8 p., 1946.

[15/] V. M. Carolin. Studies on western hemlock looper in southwest Washington in 1962. Unpublished progress report, USDA Forest Service, Pacific Northwest Forest & Range Experiment Station, Portland, Oreg., 26 p., illus., 1964.

[16/] M. G. Thomson. Studies of factors affecting reproduction in the western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst) (Lepidoptera: Geometridae). Canada Department of Agriculture, Science Services, Forest Biology Division, Interim Report 1955-4, Forest Biology Laboratory, Victoria, B.C., 41 p., 1956.

the weather station nearest the Alaskan looper infestation, showed that for the period 1950-71, September precipitation was lowest for 2 consecutive years, 1964 and 1965. In 1964, September precipitation was only 54 percent of normal; and in 1965, only 21 percent of normal. Conditions were apparently favorable for mating and oviposition then since most defoliation occurred in 1965 and 1966.

SUGGESTED ALTERNATIVES FOR PEST MANAGEMENT

The foregoing history of forest insect activity in southeast Alaska's forests during the last half century indicates that insect outbreaks have occurred infrequently relative to coniferous forests at lower latitudes, have affected vast areas, and that few insect species are involved. This situation has existed for thousands of years, and the existing virgin forests are, in part, a result of it since forests respond to all environmental influences. Therefore, a description of southeast Alaska's virgin forests as decadent is a relative term. They are decadent only in terms of production of wood fiber harvestable for man's use as compared to what might be produced under even-aged management.

From the ecological viewpoint, the virgin forests are a healthy ecosystem composed of many plant and animal organisms as well as trees, and the system is capable of restoring itself after catastrophic disturbances such as insect outbreaks. Such disturbances, although detrimental to individual trees, may be beneficial to the complex virgin forest ecosystem. This is analogous to the situation concerning beneficial effects of fire in northern coniferous forests (Heinselman 1971) and the folly of attempting to control all wildfire. The recent indiscriminate control of fire, in areas where uncontrolled fire was a common occurrence, has allowed fuels to increase to a point where a runaway fire might actually destroy the fire-resistant overstory of mature trees (Prasil 1971). The lesson here is that it may not always be wise to attempt to control a factor that is an integral part of a natural system. Therefore, perhaps the best alternative to outright control of insect outbreaks in most of southeast Alaska's remaining virgin forests is to let the outbreaks run their course and accept the fact that trees will die, but establish a flexible harvesting policy that allows for salvage of timber in areas suitable for conversion to high production even-aged management. Insect suppression may be justified in high quality, old-growth stands that cannot be salvage-logged immediately due to such factors as inaccessibility or administrative delays, or recreation areas and town sites where scenic values are high.

The philosophy for pest management or control in managed even-aged forests differs because of competition between man and pests for the same high value resource. Even in these forests insect outbreaks may occur infrequently, but if the frequency of occurrence remains comparable to what has happened before, several major outbreaks can be expected to occur in a 100-year period, the planned rotation age at which managed second-growth

stands will be harvested. In addition, new pest problems will probably arise from management-induced changes in habitat, as has happened in British Columbia (Silver 1962) and other areas (Mitchell 1970).

Although use of chemical insecticides may be justified in the management of southeast Alaska's forests, the decision to use them should be made very carefully for the following reasons. (1) The streams within Alaska's forests produce another high value resource, salmon. Application of chemical insecticides regardless of caution will probably contaminate some streams and, unless the chemical has a low vertebrate toxicity, may have some direct effect on fish. (2) Unless the chemical used is toxic only to the pest species, many beneficial insects, including parasites, predators, and aquatic insects, may be destroyed. (3) The immediate cost of insecticide application will be compounded because the initial cost must be prorated for the years remaining until the stand is ready for harvest. (4) Insecticidal treatment is merely a stopgap measure and does not reduce susceptibility of the stand to reattack. Instead, such treatment may result in a subsequent increase in the pest population. Most insecticides do not have persistent insecticidal effects, and survivors of the treatment are relieved of constraints such as intraspecific competition (Watt 1968). However, naturally occurring insecticides such as the pyrethrins or their synthetic substitutes, the pyrethroids, may have potential for use in Alaska, because they are highly toxic to the black-headed budworm and the hemlock sawfly and risk of environmental contamination is low.

Forests in drier climates are manipulated silviculturally to increase their resistance to fire. It is possible that Alaska's second-growth forests could be managed for resistance to insects. How this can be done is not known, but as we learn more about the requirements and limiting factors of potentially destructive pests the chances are increased of developing silvicultural control measures.

Clearcutting is the currently used form of timber harvesting in the region and is an accepted silvicultural technique for assuring good hemlock and spruce reestablishment on cutover lands. Generally, spruce is more abundant in the second-growth stands than in the virgin stands (Taylor 1932). This may be advantageous because most of the known pest insect species in southeast Alaska prefer western hemlock; also spruce can apparently withstand a greater degree of defoliation.

Many of the young second-growth stands are so densely stocked that they are almost devoid of ground vegetation. Thinning these stands to reduce tree competition would have the additional benefit of increasing light penetration through the canopy to allow establishment of ground vegetation. Since many insect parasite species feed during the adult stage on flower pollen and fruit of woody and herbaceous plants, thinning would tend to maintain these beneficial forms within the second-growth stands and would increase biological diversity. Also, wider leave strips between clearcuts, and more clearcuts smaller than the current average size, would

probably provide greater effectiveness of natural controls such as some parasite and bird species that normally occur on the edges of old-growth forests, but range out in search of hosts or food. Smaller clearcuts on a staggered harvesting schedule would also reduce area of single-aged contiguous "monoculture" suitable for buildup of pest populations.

Allowing alder to remain in some second-growth stands despite its inhibitory effect on early growth of spruce and hemlock regeneration may be justified for several reasons. Alder improves the stand by fixing nitrogen in the soil and by inhibiting growth of some tree pathogens in the soil (Tarrant and Trappe 1971). An increase in available nitrogen may reduce conifer susceptibility to defoliation by insects; nitrogen fertilization in Europe has had similar results (Francke-Grosmann 1963). Retaining alder would also increase stand diversity which is less desirable for insect buildup.

Perhaps entomologists should be involved with other specialists in determining what areas could be safely converted to even-aged management and how timber sales should be laid out in order to create insect-resistant, second-growth stands. Pest problems that arise due to management practices, as they have in other areas (Graham 1956, Lejeune 1962), could be averted or minimized.

Another way in which pest problems might be reduced would be to import parasites and predators that do not now occur in southeast Alaska. This is an extremely complex problem that requires much study for several reasons. For example, parasites that attack pests such as the black-headed budworm and the hemlock sawfly in the Pacific Northwest and British Columbia but not in Alaska probably cannot be successfully introduced; otherwise, they would probably now occur in Alaska.

Parasites that occupy similar habitats in areas with climate, fauna, and flora comparable to southeast Alaska should be considered for introduction. The spruce-fir forests of northern Japan are a potential source. The black-headed budworm parasite complex in the Maritime Provinces of eastern Canada (Miller 1966) should also be considered as a source. Such species would have to be tested intensively prior to introduction to assure that (1) they could successfully parasitize Alaskan pest species, (2) Alaska's climate was amenable to their survival, (3) the flora of Alaska was suitable for needs such as supplementary feeding for adults and, most important, (4) the introduced parasites would not compete with native species to the point that their combined effect on the pest population would be less than before introduction. In any case, the decision to introduce exotic species to an area should not be made without careful analysis (Townes 1972).

Apparently, some niches exist in southeast Alaska that could be filled by introduced parasite species. Hemlock sawfly eggs and free-feeding larvae are almost completely free of parasite attack (Torgersen 1968, 1969), and only one species is known to parasitize black-headed budworm

eggs in the west (Torgersen 1970). Ideally, an introduced species should be capable of successfully parasitizing several host species in order to maintain a viable population that could exert immediate control on a different host that suddenly increased in numbers. One of the major parasites of the sawfly and the budworm which also parasitizes the hemlock looper is *Itoplectis quadricingulatus* (Prov.). Its effectiveness against any host may be partially contingent on maintenance of a population on an alternate host in the same or nearby areas.

Parasites and predators generally cannot cause a pest epidemic to collapse before significant damage has been done, because their response to increase in host numbers is usually delayed, especially if they have only one generation per year. They are important pest regulators, however, and forests should be managed to maximize their effect.

Probably a more effective way to reduce pest populations to tolerable levels is through the manipulation of naturally occurring disease organisms because they are virulent, do not normally compete detrimentally with parasites and predators, and do not cause environmental contamination (Cameron 1971). Unlike chemical insecticides whose virulence may be reduced by evolution of resistant insect strains, these biological insecticides (or pathogens) are also capable of evolving in response to evolved resistance in their insect hosts.

In drier areas, the best candidates for such use are viruses and bacteria because they are more amenable to manipulation than are the fungi. However, in the cool, moist forests of southeast Alaska the pathogenic fungi might show more promise. In British Columbia, encouraging experimental results have occurred through manipulation of the fungus, *Cordyceps*, in controlling the green-striped forest looper.[17/] Another important reason for considering fungi is that they can be cultured easily on artificial media (Tanada 1967). Development of such materials to the operational stage requires much experimentation, testing under laboratory and field conditions, and approval by the Federal Environmental Protection Agency before they can be used. This is a lengthy, expensive process but should be considered. Viruses and fungi that occur naturally in black-headed budworm and hemlock sawfly populations are potential candidates for manipulation in southeast Alaska.

In the past 20 years, a biological insecticide in the form of a bacterium, *Bacillus thuringiensis* Berliner, has been cultured and sold commercially under the name of Thuricide.[18/] This material has little or no toxic effect on most parasites and predators. It kills plant-feeding moth larvae both by infecting and killing the insect directly and by producing a substance toxic to insects.

[17/] Personal communication with Roy Shepherd, Research Entomologist, Victoria, B.C.

[18/] Mention of products by name is for the information and convenience of the reader and does not constitute an official endorsement or approval of any product by the U.S. Department of Agriculture to the exclusion of others which may be suitable.

A commercial formulation of the bacterium and toxin was tested experimentally against the black-headed budworm in Alaska with some success (Schmiege and Hard 1966a). In this very limited laboratory test performed at field temperatures and humidities and using several concentrations of Thuricide on dipped foliage, the highest mortality to budworm larvae was 81 percent. The experiment was terminated after 120 hours of larval exposure to this material on hemlock foliage; but, if the test had been run longer, mortality might have been higher due to delayed effects of actual bacterial infection.

Use of *B. thuringiensis* to control the spruce budworm in Canada has been unsuccessful because susceptibility of budworms is dependent on larval age, physiological condition, and environmental temperature. Recent studies show that addition of an enzyme, chitinase, to the bacterial formulation increased the infectivity rate of the bacterium to budworm larvae and increased efficiency of the bacterium at lower temperatures (Smirnoff 1972, Smirnoff et al. 1972). Chitinase is an enzyme produced naturally by insect-killing fungi that enables fungal spores to penetrate the layer of chitin in the insect integument or gut. Until recently, it was produced commercially in small quantities by culturing certain bacteria and fungi and was very expensive. Now the enzyme can be extracted cheaply in large quantities from viscera of slaughtered domestic fowl (Smirnoff 1972). This discovery may result in a more extended use of *B. thuringiensis* as a biological insecticide. Since the bacterium does not become permanently established in a pest population, it has the disadvantage of expense in repeated application. However, it does not contaminate the environment whereas use of a chemical insecticide could.

Economics will dictate the need for control of pest populations in the second-growth forests of southeast Alaska, but the means used will be largely determined by existing techniques and acceptability of side effects. Although a number of alternative approaches varying in effectiveness and cost have been presented, probably the least expensive approach in the long run, environmentally as well as monetarily, is to anticipate potential pest problems and attempt to forestall them through cultural manipulations of the forest and natural control factors. This will not completely eliminate the need for expensive pest control practices such as the application of insecticides, but it will reduce the need for them.

SUMMARY

Relatively few insect species are destructive to the forests of southeast Alaska, and weather during the growing season appears to be a major limiting factor in their activity. Two defoliators, the black-headed budworm and the hemlock sawfly, have caused the most damage in the past, primarily to forests south of Frederick Sound. However, much of the virgin forest in southeast Alaska is all-aged and defoliator outbreaks that resulted in extensive top-kill and complete tree mortality have not, to our knowledge, destroyed entire stands.

Insects and their host trees have been evolving together for thousands of years, with each responding to changes in the other. Thus, it is quite possible that the insects, though destructive to individual trees, are actually beneficial to the virgin forest ecosystem. Insects are obviously partly responsible for the present structure of southeast Alaska's virgin forests. Therefore, it is important to understand that they are not intruders but a natural and perhaps necessary component of the system.

As more virgin forest is harvested and converted to managed stands, what are now potential insect pests may become actual pests for a variety of reasons, but primarily because of increased competition with the forest manager for a resource in which he is investing time and money and expects maximum return.

Pest problems have intensified in nearby coastal British Columbia as more forest land has been placed under management; similar problems can arise in southeast Alaska for the same reason. Potential pest problems could be averted in some cases through silvicultural practices. However, since many of the requirements and limiting factors of the potential pest species are as yet unknown, effective silvicultural practices cannot always be prescribed. Thus, the alternative may be direct pest suppression methods.

Alternative approaches such as insecticide application, parasite introduction, and manipulation of microbial disease organisms will not be operationally feasible until more research has been completed. Of the three alternatives, insecticides may be most attractive to the manager because their operational use could be developed most rapidly. However, use of certain insecticides could be disadvantageous, on both a short- and long-term basis, because it could be detrimental to the salmon resource in southeast Alaska, and it would be a stopgap measure that does not reduce stand susceptibility to attack. The pyrethrins and the biological insecticide, *Bacillus thuringiensis*, are prime candidates for further testing against major defoliators if the insecticide alternative is given top priority because they are potent, have low vertebrate toxicity, and risk of environmental contamination is low.

The forest manager's current, most realistic approach to insect pest management in virgin stands based on biological and economic considerations may be to do nothing to suppress widespread outbreaks. He should allow them to run their course but establish a flexible harvesting policy that allows for salvage of good quality timber in damaged areas and conversion of nonproductive old growth to more productive even-aged stands.

The manager's primary approach to insect control in intensively managed stands should be prevention, assisted by suppression. Prevention, which consists largely of stand manipulation to maximize effects of natural insect mortality factors, will usually eliminate need for insect suppression. However, suppression, which usually involves use of insecticides, may be required in areas with high commercial or esthetic values where failure to control could result in heavy losses.

OUTLINE OF FOREST INSECT RESEARCH NEEDS

1. TREE PESTS
   - A. Continue population studies to determine and quantify key mortality factors.
   - B. Develop additional sampling techniques.
   - C. Develop techniques to determine actual forest losses caused by insects.
   - D. Identify silvicultural techniques that inhibit growth of pest insect populations.
   - E. Test safe insecticides and naturally occurring pathogens against laboratory and field populations of potentially destructive insect species.

2. AQUATIC INSECTS
   - A. Determine taxonomy and life histories.
   - B. Determine relative importance of various species and stages of development as a source of food for trout and juvenile coho salmon.
   - C. Determine and quantify physical factors that limit aquatic insect populations.
   - D. Determine effects of various forest management practices on the limiting factors and subsequent effect on aquatic insects.
   - E. Develop sampling techniques to measure effects of insecticidal treatment of stands on aquatic insects.

3. SOIL INSECTS
   - A. Determine taxonomy and life histories.
   - B. Determine importance regarding conversion of slash and litter to soil.
   - C. Determine and quantify physical factors that limit soil insect populations.
   - D. Determine effects of various forest management practices on soil insects.

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Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

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2. Development and evaluation of alternative methods and levels of resource management.
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The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research will be made available promptly. Project headquarters are at:

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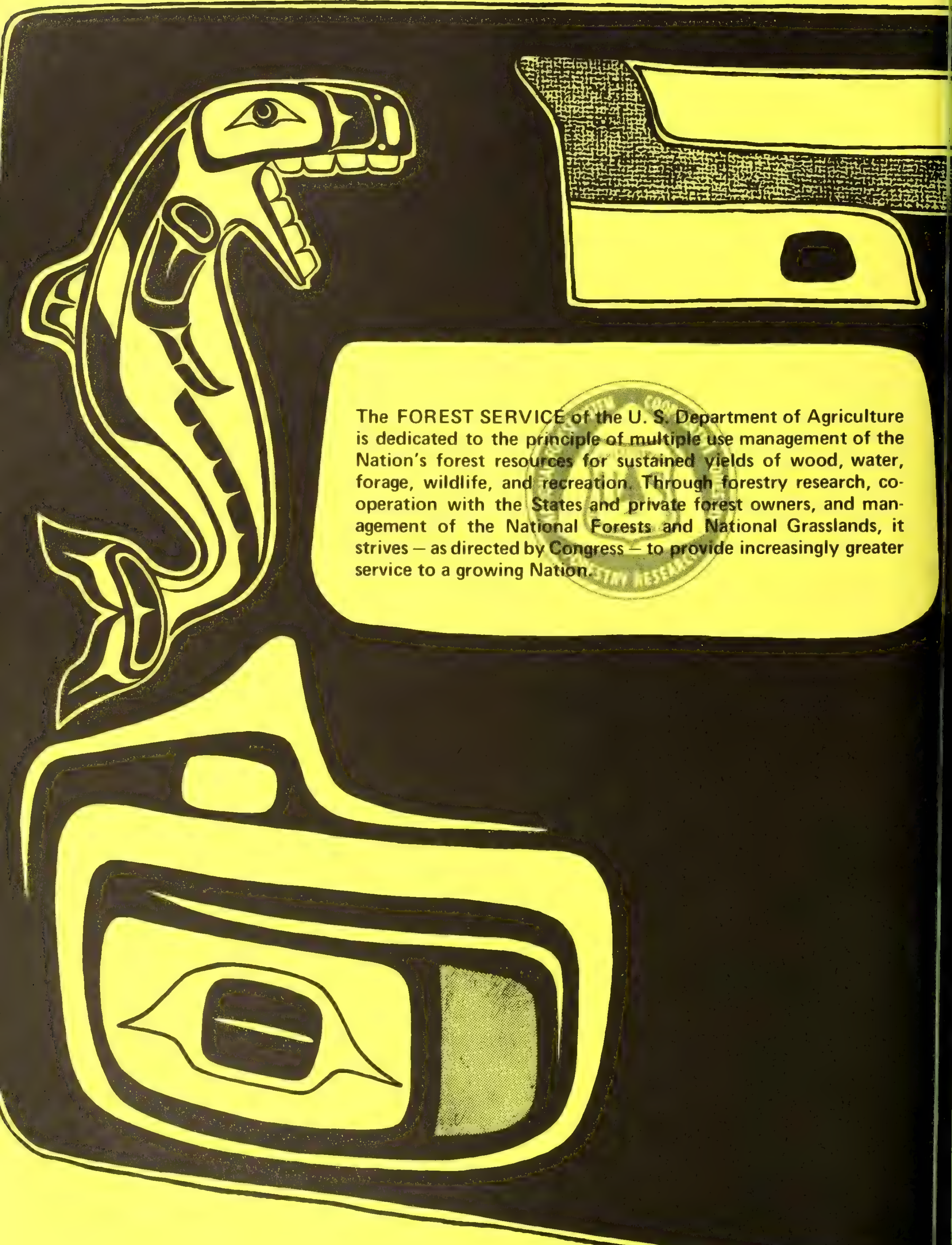

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1974
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herbicidal drift control:

aerial spray equipment, formulations, and supervision

PROTECT
Use Pesticides Safely
FOLLOW THE LABEL
U.S. DEPARTMENT OF AGRICULTURE

h. gratkowski

pacific northwest forest and range experiment station
u.s. department of agriculture forest service
portland, oregon

ABSTRACT

Public concern over environmental pollution requires increasingly sophisticated procedures when herbicides are used in silviculture. Many specialized aerial application systems and spray additives have been developed to reduce drift of herbicidal sprays. This publication provides forest-land managers with a brief description of these aerial spray systems and additives. Personnel and supervision to insure proper use of equipment and additives are also discussed.

Keywords: Herbicides, brush control, environment, silviculture.

PESTICIDE PRECAUTIONARY STATEMENT

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

During the past 20 years, aerial application of herbicides has developed into an effective silvicultural tool in the Pacific Northwest. During the same period, however, the world's rapidly increasing population and the industrial expansion required to satisfy its needs have seriously damaged the biosphere. Everywhere, people are becoming concerned about deterioration of the environment. They are now quickly antagonized by any public or industrial activity that may add to pollution. Herbicides, with their startling, eye-catching effects on vegetation, have attracted more than their share of this antagonism.

Although foresters have an impressive record in safe use of herbicides, we must become even more selective in deciding on treatment and more precise in applying herbicides. If a site requires treatment, we must restrict our sprays to that area and prevent drift onto adjacent areas.

FACTORS AFFECTING SPRAY DRIFT

Drift refers to the airborne movement of herbicidal spray from the site of application to untreated areas in the vicinity. This movement may be in the form of vapors, droplets, mists, aerosols, dusts, or other fine spray particles.

To a great extent, spray drift depends upon droplet size--large droplets fall more quickly and drift less than smaller ones. Theoretically, with no evaporation and a nonturbulent 5-mile-per-hour breeze, droplets 300 microns in diameter would drift only 42 feet while falling 50 feet (table 1). Under similar conditions, smaller 100-micron droplets could drift 375 feet (Hansen 1965).

Smaller droplets not only drift farther; they are also more likely to evaporate and be lost before reaching the vegetation. Seymour (1969) calculated that droplets 100 microns in diameter will evaporate

Table 1.--Predictable drift of different sized droplets when sprayed at 50 feet[1/]

Diameter of droplets	Cross wind		
	1 mile/hour	5 miles/hour	10 miles/hour
--microns--			
10	1.5 miles	7.5 miles	14.5 miles
100	75 feet	375 feet	750 feet
300	8 ft. 4 in.	42 feet	83 feet
590	2 ft. 2 in.	10 ft. 8 in.	21 ft. 5 in.
800	1 ft. 3 in.	5 ft. 9 in.	12 feet

1/ Reproduced with permission of Hercules, Inc. (Hansen 1965).

after falling only 3 feet (fig. 1). Under the same conditions, larger droplets 200 microns in diameter could fall more than 20 feet without evaporating.

When spraying cuttings on rough, mountainous terrain, flying height must often be 50 feet or more above the vegetation; it may exceed 100 feet where flight lines are obstructed by snags or tall trees. In such areas, drift and evaporation may result in loss of more than half the active ingredients when applying phenoxy herbicides. Approximately 60 to 75 percent of low volatile esters of 2,4,5-T in diesel oil were lost from an early spring aerial application in the Oregon Coast Ranges (Norris 1967). To reduce drift and evaporation and to insure pilot safety, all dead trees and weed trees more than 10 feet tall should be felled during logging.

Flying speed is another critical factor; shearing and fragmentation of droplets by the airstream can produce large numbers of tiny, drift-susceptible droplets. As speed increases, the number of mistlike droplets also increases. Even at minimum safe speeds, shattering of spray in the airstream can almost obscure differences in droplet size and spray pattern produced by most commonly used aerial spray nozzles.

For adequate drift control, median diameter of herbicidal spray droplets should be approximately 400 to 600 microns. But as droplet size is increased, we get a smaller number of droplets per gallon and the number of hits on foliage decreases proportionately. We **must**, however, have a sufficient number of droplets per square foot to insure adequate coverage

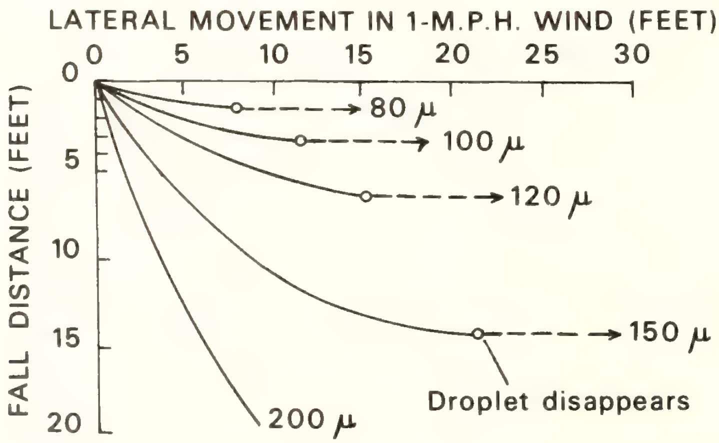

Figure 1.--Relation of vertical fall through air to lateral movement for water droplets falling at terminal velocity in a 1-mph wind. Calculated for 25° C., 50 percent RH, 760 mm Hg, and lateral air movement. (Adapted from "Pesticidal Formulations Research," with permission of The American Chemical Society (Seymour 1969).)

for brush control; incomplete coverage allows many species to survive herbicidal sprays. Therefore, as we increase droplet size, we may also need to increase spray volume and perhaps amount of herbicide applied per acre as well.

With conventional booms, we are somewhat limited in efforts to increase droplet size. We can vary formulations or change nozzle type and nozzle orientation on the spray boom. We can also change orifice diameter, whirl plates, and pump pressure. Droplet size increases as we change from flat fan to narrow angled hollow cone to jet nozzles without whirl plates. Larger droplets are also produced as orientation of nozzles is changed from straight down to back along the airstream (fig. 2). And finally, lower pump pressures will produce larger droplets.

At best, however, conventional booms on helicopters produce a large number of fine droplets and mist that are drawn up in whorls off each end of the spray boom. The whorls carry the fine droplets high above the helicopter, where they are most likely to drift with the wind or evaporate and drift away as vapor. Although the swirling vortices increase plant coverage and swath overlap, they also increase spray loss by drift and evaporation.

Foresters have already imposed many restrictions to reduce drift and other spray losses. Evaporation is reduced by using only low volatile esters and by spraying only when air temperature is below 75° F. and relative humidity above 50 percent. To minimize drift, aerial spraying is stopped when windspeed exceeds 6 miles per hour. In addition, aerial sprays are applied from minimum safe flying heights above vegetation, and flying speed must not exceed 50 miles per hour.

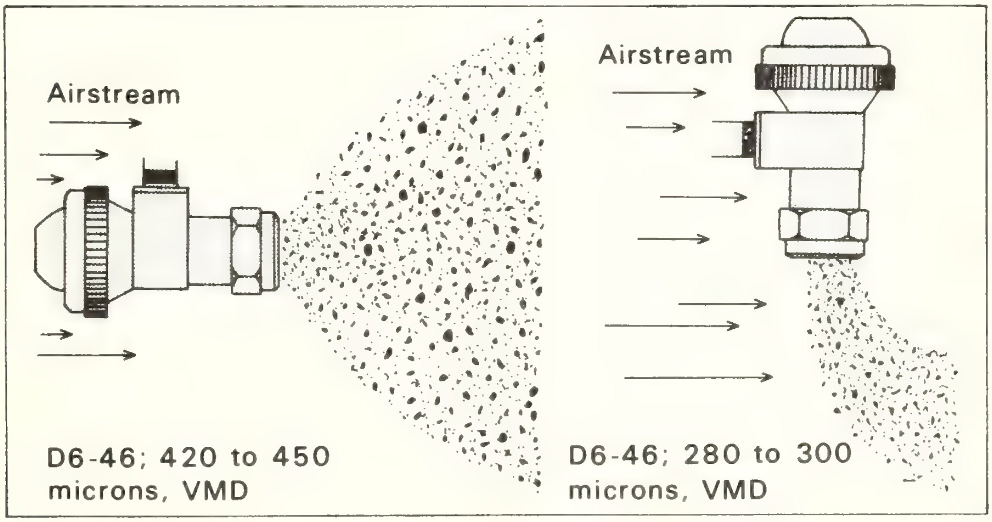

Figure 2.--Variation in droplet size resulting from change in nozzle orientation on the spray boom. VMD = volume median diameter--half of spray volume is in droplets of this diameter or larger; half is in droplets of this diameter or smaller. D6-46 refers to spraying system's D6 disk backed up by a 46 whirlplate (any nozzle that produces droplets in the same range can be substituted). (Adapted from Brazelton (1971), with permission of University of California Cooperative Extension Service.)

DRIFT REDUCTION

Three items must be considered if we are to reduce drift in an aerial spray operation: (1) aerial spray equipment, (2) formulations and spray adjuvants, and (3) project personnel. A good understanding of 1 and 2 are necessary to obtain large droplets for drift reduction and still get adequate spray coverage for acceptable effects on vegetation. But even the best formulations and equipment will not prevent damage on adjacent areas unless the spray is applied by a well-trained and responsible pilot with proper help and project supervision.

There are two ways to increase droplet size. First, by using special spray equipment that will produce droplets of the desired size. Or second, by using special formulations and spray additives to get the same result.

Aerial Spray Equipment

Helicopters are more expensive to operate but have proved far more useful and adaptable than fixed-wing aircraft for spraying forest land in the steep, mountainous terrain of the Pacific Northwest. Helicopters are highly maneuverable and allow more accurate spraying along edges of cuttings, buffer strips, and ecologically sensitive areas. They can fly at low height and slow speed over the steepest terrain, where fixed-wing aircraft must fly at greater height and higher speed to insure safety of the pilot.

In addition, helicopters can operate from heliports on roads and landings in the immediate vicinity of the spray areas. This minimizes ferry time in reloading and eliminates possible contamination of streams and farmlands in flying cross country from airports or landing strips needed for fixed-wing aircraft.

Many specialized types of aerial spray systems to reduce drift have been developed during the past 15 years. Most are designed or adaptable for use on helicopters. For herbicides in conventional carriers, the Microfoil Boom is most useful. Others, such as Amchem's Spra-Disk, the Rhodia Visko-Rhap, and Stull Bi-fluid spray systems were developed to apply invert emulsions. The Dow R-511 helicopter spray system was designed to apply particulated sprays, but a modified form of the R-511 has also proved effective in applying thickened sprays and tank-mixed invert emulsions. Most recently, foam spray systems were developed. These only require substitution of special nozzles on conventional booms to produce foamed sprays of herbicides in water or oil-in-water emulsions.

MICROFOIL BOOM

The Microfoil Boom developed by Amchem Products, Inc. is the only aerial spray system specifically designed to reduce drift using conventional carriers of water, oil, or oil-in-water emulsions. Thickening agents, invert emulsions, or particulating agents are not needed.

In aerial spraying, shearing and production of fine spray droplets can be greatly reduced by releasing spray through an open tube directed back along the airstream. The Microfoil uses this principle to produce nearly uniform large droplets with a minimum number of fine droplets.

The Microfoil is specifically designed for helicopters; it is not adaptable for fixed-wing aircraft. Boom length can be varied from 10 to 26 feet by bolting 3- or 5-foot sections of the boom together. Swath width varies with boom length, pump pressure, flying height, and--to some extent--with size of orifice selected.

The Microfoil boom consists of a

double tubing to equalize pressure with a series of airfoil-shaped nozzles mounted behind the trailing tube. Each Microfoil nozzle is 6 inches long with 60 needlelike tubes projecting from the trailing edge. Streams of spray solution are released through the needlelike tubes into the nonturbulent airstream behind the airfoil-shaped nozzles; a 26-foot boom has 3,120 orifices on 52 nozzles (fig. 3). Two orifice sizes are available--0.013- and 0.028-inch inside diameter. These produce droplets with mean diameters of 800 microns and 1,700 microns, respectively (Kirch 1968).

The Microfoil lays down a sheetlike pattern of spray that falls cleanly behind the helicopter and allows close, accurate placement of spray along boundaries. Drift control was excellent on the Siuslaw National Forest, where little drift was

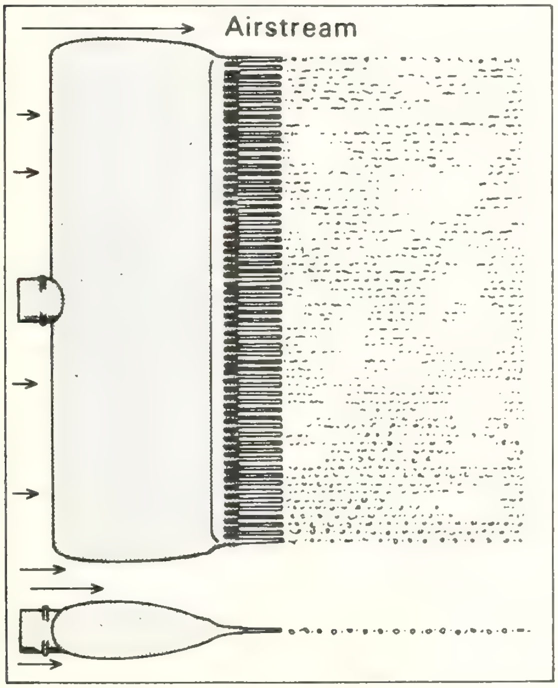

Figure 3.--Top and cross sections of a Microfoil nozzle. (Adapted from Brazelton (1971), with permission of University of California Cooperative Extension Service.)

observed with windspeeds up to 12 miles per hour.

The Microfoil appears better adapted for foliage spraying than for stem treatments in dormant or bud-break spraying. Average defoliation from bud-break sprays on red alder and tanoak in the Siskiyou National Forest was nearly comparable to that obtained with a conventional boom and D8 nozzles. In a bud-break spray on alder on the Siuslaw National Forest, however, more of the large Microfoil droplets passed through the leafless branches to be lost on the forest floor.

There are several disadvantages in the Microfoil: (1) the needlelike jets are easily clogged or broken, (2) excessive pump pressure can split the plastic bodies of nozzles, (3) some helicopters are not readily adapted to use the Microfoil, and (4) the sheetlike pattern falls behind the pilot where spray coverage is difficult to observe and skips (unsprayed strips) are common.

SPRA-DISK

This apparatus was developed by Amchem Products for helicopter application of invert emulsions, since conventional spray systems had proved unsuitable for use with thick inverts (Gratkowski and Stewart 1973). The Spra-Disk has been useful in spraying utility rights-of-way but has not been used much in spraying forests.

Briefly, the Spra-Disk operates on gravity flow and centrifugal force. The thick invert emulsion flows from the saddle tanks through large-diameter feedlines into a hollow disk mounted beneath the helicopter bubble. An electric motor spins the disk, and centrifugal force carries the invert emulsion out through 12 nozzles mounted on the perimeter of

the disk. Centrifugal force is controlled by the pilot through a rheostat that varies speed of revolution of the disk. By changing height above vegetation and varying speed of revolution of the disk, spray swath can be varied from 20 to 50 feet.

VISKO-RHAP AND STULL BI-FLUID

These spray systems are similar in operation. Both are designed to apply invert emulsions. The Stull system was developed by the Stull Chemical Company; the Visko-Rhap system by Hercules, Incorporated. The Visko-Rhap system is now marketed through the Simplex Manufacturing Company of Portland, Oregon, by Rhodia, Incorporated.

Both systems require special invert formulations containing "flash" emulsifiers. As bifluid systems, they depend upon an instantaneous or "flash" formation of the invert emulsion in flight just before discharge through the nozzles. In flight, the oil and the water phases of the spray are carried in separate tanks and pass through separate lines to the mixing chamber. In the Stull system, the invert is formed in a special mixing and metering chamber just before it reaches the pump. In the Visko-Rhap system, the two phases are metered into a pump inverter, which forms the invert and pumps the spray through the system. In both systems, the invert emulsion is then discharged through nozzles spaced along a standard length spray boom.

Both the Stull and Visko-Rhap systems are suitable for use on forest lands. The Stull system has provided acceptable brush control on southwestern forest and range land for about 10 years.

DOW R-511

The Dow Chemical Company's R-511 spray system was specially designed for helicopter application of thick, granular sprays of Tordon 101 Mixture thickened with Norbak particulating agent. The R-511 is more suitable for spraying utility rights-of-way than forest lands.

Basically, the R-511 system consists of a powerful positive displacement pump, extra-large hoses and supply lines, and a cluster of five nozzles centered between the skids ahead of and below the cockpit bubble. The center nozzle has a flat-fan spray tip with an orifice diameter of 0.04 inch or larger. The other nozzles are offcenter nozzles that spray outward; their angle of discharge can be changed in flight to control swath width. In flight, the pilot can vary swath width from 25 to 50 feet while maintaining a constant per-acre application rate with a flow control valve.

MODIFIED R-511

The modified form of the Dow R-511 is better suited for application of thickened sprays on forest land. This version has the five nozzles spaced across a short boom about 8 feet long, with the outer nozzles spraying outward to increase swath width. This modification produces a wider swath than that obtained with the R-511.

This unit seems very adaptable and useful for forest spraying. A modified R-511 has already been used in applying Vistik-thickened, Norbak-thickened, and tank-mixed invert emulsion sprays on the Siuslaw National Forest. With some variation in pump pressure and number and types of nozzles, it should be possible to apply herbicides in conventional carriers as well as thickened sprays.

FOAM SPRAY SYSTEMS

Foam spray application only requires substitution of specially designed foam nozzles on conventional aerial spray booms. Foam nozzles consist of an adapter nut, a special flow control disk and strainer, a foam generator body, and a special nozzle tip. These replace the normal orifice tips and cores of standard aerial diaphragm nozzles. The flow control disk and strainer replace the standard strainer. Boom pressures of at least 40 p.s.i. (pounds per square inch) are generally recommended for applying foam sprays.

Formulations and Spray Adjuvants[1/]

Aerial spray drift can also be reduced by use of invert emulsions or spray adjuvants. Those now available may be classified as: (1) invert emulsions, (2) spray thickeners, (3) particulating agents, or (4) foaming agents. All are designed to reduce drift by increasing droplet size. This is accomplished by increasing viscosity of the spray solution or by producing a larger particle or globule that contains the herbicide. No formulation will completely eliminate drift; all produce some small, driftable droplets.

INVERT EMULSIONS

Invert emulsions are thick, creamy or mayonnaiselike mixtures of low volatile esters with oil and water that have been available for more than 10 years. Generally, invert emulsions have not been as effective as equal amounts of herbicides in normal oil-in-water emulsions or oil carriers (Phillips 1963).

In invert emulsions, small water droplets are dispersed within oil. In contrast, the more commonly used oil-in-water emulsions have oil droplets dispersed throughout a much larger volume of water. Invert emulsions contain far more oil (15 to 25 percent by volume) than normal oil-in-water emulsions (5 to 10 percent by volume).

Many special commercial formulations of herbicides that will produce invert emulsions are available. Those containing low volatile esters of 2,4-D and 2,4,5-T are most widely used for woody plant control.

Invert emulsions reduce spray drift by increasing the number of large droplets. Drift is not entirely eliminated, however. Inverts, like all formulations, produce some small droplets during application. As with conventional carriers, the number of small droplets produced depends upon such factors as viscosity of the invert emulsion, nozzle tips, orifice size, boom pressure, flying speed, and nozzle orientation on the spray boom.

Viscosity (thickness) of invert emulsions depends upon the ratio of oil to water and upon the size of water droplets produced by agitation. In the field, viscosity can be changed by changing the amount of oil. As more oil is added, an invert emulsion becomes thinner and more fluid. Very thin inverts can be applied through conventional aerial spray systems.

Special aerial spray equipment is needed to apply thick invert emulsions. Type of equipment required depends upon the commercial product used.

Amchem's Spra-Disk or Dow's R-511 can be used to apply thick invert emulsions. For these, the invert emulsion is premixed

[1/] More detailed information on formulations, mixing, and use of spray additives is provided in General Technical Report PNW-3 (Gratkowski and Stewart 1973).

in a nurse tank and then pumped into the saddle tanks of the helicopter.

The Visko-Rhap and Stull Bi-fluid spray systems require special commercial formulations. These bifluid systems depend upon an instantaneous or "flash" formation of the emulsion in flight; therefore, the commercial product must contain a flash emulsifier. Label instructions specify whether the herbicide should be added to the oil tank or to the water tank on the helicopter. **Invert emulsions for Bi-fluid systems are never premixed in a separate nurse tank**.

THICKENING AGENTS

Three commercial thickening agents are available at present. These are Vistik, Dacagin, and Lo-Drift. All are water soluble and increase droplet size and reduce drift by increasing the viscosity (thickness and flowability) of the water in herbicidal spray mixtures. **None of these can be used to thicken oil carriers**.

Vistik.--Vistik is a chemically inert cellulose product that looks and feels like flour. When applied during the proper season, Vistik did not reduce effectiveness of 2,4,5-T or 2,4,5-T/TCA mixtures on woody plants in the east (Suggitt 1965) nor that of paraquat on crop plants in Oregon (Ekins et al. 1970). However, it did reduce defoliation of salmonberry treated in late August--a season generally too late for good control of salmonberry.

Vistik can be used to thicken herbicides in water carriers or in oil-in-water emulsions. Such sprays may be in the form of solutions, emulsions, or suspensions of wettable powders. It has been used with amitrole-T, phenoxy esters and amines, picloram, and silvex. Vistik will thicken only the water phase of such spray mixtures. Four to 6 pounds are normally added per 100 gallons of spray. During the past 2 years, 4 pounds of Vistik per 100 gallons of spray mixture has provided acceptable drift control with phenoxy herbicides and with amitrole-T.

Vistik-thickened sprays are fluid and can be applied through conventional aerial spray booms. For aerial spraying, D8 or D10 hollow cone tips without whirl plates are used on standard diaphragm tee-jet nozzles. Pump pressure should be 25 to 35 p.s.i., depending upon viscosity, nozzle tips, and desired rate of discharge. Vistik-thickened sprays can also be applied with the modified R-511 spray system.

A Vistik viscosity cup should be used periodically to check viscosity of Vistik-thickened spray in the mixing tank. For aerial spraying from approximately 80 feet above vegetation, the mixture should take 75 to 80 seconds to drain from a filled cup. If a tank of Vistik-thickened spray is left standing in the sun, viscosity will decrease as the solution warms. More Vistik may be added (with agitation) to maintain the desired viscosity.

Dacagin.-- Dacagin is a dry, granular material that forms a gel when mixed with water or oil-in-water emulsion carriers. As with Vistik, Dacagin thickens only the water phase of the carrier. The gel can be used as a carrier for water soluble herbicides, emulsifiable chemicals, and wettable powders. Examples are amine salts and ester formulations of 2,4-D and 2,4,5-T and wettable powders such as atrazine or dalapon. Dacagin does not seem to affect herbicidal activity. On shrubs and weed trees in northwestern California, Dacagin-thickened sprays appeared as effective as the same herbicides and carriers without Dacagin.

Unlike Vistik sprays, Dacagin gels do not become more fluid while standing. However, the gels have the unusual property of decreasing in viscosity while being agitated or pumped but regaining their initial viscosity after agitation stops. In practical terms, this allows herbicides in Dacagin gels to be applied with ordinary aerial spray equipment. The gel thins while moving through the spray lines and boom but thickens again to produce large droplets after discharge from the nozzles. Therefore, special application equipment is not required.

Although conventional aerial spray equipment can be used to apply Dacagin gels, the modified R-511 should also be suitable. All screens in supply lines and nozzles must be 50 mesh or larger. Pump pressures should be 25 to 35 p. s. i.

Lo-Drift.--Lo-Drift is a new product--a water soluble polyvinyl polymer designed for use with herbicides in water carriers. It differs from Vistik and Dacagin in that it: (1) is a liquid, (2) requires a wetting agent such as Multi-film X-77 to activate the polymer. Lo-Drift may be used with herbicides in either water carriers or oil-in-water emulsions. Like Dacagin gels, aerial sprays thickened with Lo-Drift can be applied with conventional aerial spray equipment. Limited data indicate that Lo-Drift did not change activity of six different herbicidal formulations on several agricultural crop plants.

Only very small amounts of Lo-Drift are required in herbicidal sprays. For aerial application of herbicides in water carriers, at least 32 fluid ounces of Lo-Drift must be added per 100 gallons of spray.[2/]

[2/] Change from recommendation in General Technical Report PNW-3 (Gratkowski and Stewart 1973). This new recommendation is based upon aerial spray tests conducted on the Umpqua National Forest after General Technical Report PNW-3 was published.

The thickened spray has a viscosity like that of mineral oil and is easily pumped through conventional spray booms with a 30-p. s. i. boom pressure. D8 nozzles without whirl plates are used on conventional booms; the nozzles directed back along the airstream at an angle not greater than 30 degrees from horizontal. All screens in supply lines and nozzles should be 50 mesh or larger.

Lo-Drift O.S.--Early spring herbicidal sprays on red alder, vine maple, and other deciduous species in the Pacific Northwest are applied in oil carriers. Oil is needed to carry the chemical through the bark of the leafless branches. Since oil with its low surface tension produces even more fine droplets than water carriers, a thickening agent for oil carriers is urgently needed to control drift in early spring aerial spraying.

Lo-Drift O. S. (oil soluble) is the only spray thickener designed for use with oil carriers. Lo-Drift O. S. is still in the developmental stage. Project-scale trials to determine its effectiveness in reducing drift of herbicidal sprays and to measure its influence on herbicidal activity are in progress on several National Forests in western Oregon.

PARTICULATING AGENTS

Norbak (Dow Chemical Co.) is the only particulating agent available at present. It is a water swellable plastic polymer that looks and feels like granulated sugar.

Unlike thickening agents that increase the viscosity of water, each Norbak granule absorbs the water of spray solutions and swells to a fixed size. Any herbicide dissolved in the water will also be absorbed.

Norbak is especially useful for herbicides that are soluble in water. These

include amines and metallic salts of 2,4-D or 2,4,5-T. Such formulations will be imbibed with the water. If used with esters of phenoxy herbicides or with wettable powders such as atrazine or dalapon, only the water phase of the spray will be absorbed.

Effects of Norbak on herbicidal activity are contradictory. Byrd and Reimer (1966) found no reduction in effect of picloram, but Ekins et al. (1970) state that Norbak reduced the activity of paraquat on field crops. Unfortunately, good comparisons are not available for woody plants. It seems possible, however, that clumping of Norbak particles and absorption of some herbicide into the particles could reduce absorption of herbicides from Norbak on plant surfaces. If true, this could reduce effects of herbicides in the low volume sprays used on forest-land shrubs and weed trees.

Because granular Norbak-particulated sprays are much thicker than viscous sprays thickened with Vistik, Dacagin, or Lo-Drift, agitation in the mixing tanks, pumps, and spray equipment must be more powerful. Mixing tanks should have the best mechanical agitation possible. The transfer pump must be a positive displacement pump. The tank must have a bottom outlet, and the pump should be mounted below that level. All hoses and supply lines must be 1-1/2 inches or larger in inside diameter and as short as possible.

Norbak sprays can be applied only with the Dow R-511 or possibly the modified R-511 with short boom. The R-511 is used only on utility rights-of-way; the modified R-511 can be used in forest spraying as well as on rights-of-way. In either case, nozzles should have flat-fan tips or cone tips without whirl plates and orifice diameter of nozzles should be 0.04 inch or larger. The spray boom must be at least 1.20 inches inside diameter with a minimum spray pressure of 20 p.s.i. at the end of the boom.

FOAM SPRAYS

Foaming agents are the newest spray additives designed to reduce drift. Foam sprays are easier to store, transport, mix, and apply than invert emulsions or thickened sprays. Basic components of this system are: (1) a water soluble liquid containing the foaming agent, stabilizers, and wetting agents; and (2) specially designed nozzles that mix air into the spray to create a foam.

Field trials indicate that foam sprays provide good drift control and do not reduce effectiveness of herbicides. Foam carriers were used on alder, salmonberry, and thimbleberry in a State forest and a National Forest during July and August 1972. Observation several months later indicated results comparable to the same materials in normal carriers.

Several foaming agents are available. Trade names of a few are Accutrol, Foamspray, and Fomex. Each company specifies that a certain type of foam nozzle be used with its product. **Only the nozzles recommended by the manufacturer of the foaming agent should be used.** The nozzles are designed to fit the air-to-liquid expansion ratio of the foaming agent.

Foaming agents can be used with water carriers and oil-in-water emulsions. This would include water soluble herbicides, esters of phenoxy herbicides, and wettable powders such as atrazine. **Foaming agents should not be used with oil carriers.** Rates are low--1/2 to 1 gallon per 100 gallons of spray; the higher rates are used with emulsions. Foamed sprays are applied with conventional aerial spray equipment modified only by substituting

special foam nozzles in place of standard tips and cores (see page 7).

PERSONNEL AND SUPERVISION

Finally, effective drift control on any aerial spray job requires more than familiarity with special spray equipment, formulations, and additives. Well-trained personnel are a necessity to assure full benefit from this preparatory work. Above all, the keyman on any spray project is an expert pilot. His skill and judgment will assure best results from carefully selected formulations and equipment and insure that spray is applied only on the target area. If the pilot fails, all precautions and work are wasted and an area that should have been protected gets sprayed.

At least three men are needed to properly supervise aerial spraying on forest land. One is the supervisor or COR (contracting officer's representative) at the heliport. The other two are observers who follow and observe the operation on the ground. All three should be thoroughly familiar with the area--especially the sites to be sprayed. Each should have his own vehicle and two-way radio. The pilot should also have a two-way radio as part of the net. In this way, the supervisor and pilot can immediately be notified of sudden changes in weather conditions or other factors on the spray areas, and the observers can be notified of any changes in plans and rerouted to alternate sites.

Before spraying begins, the COR should supply the pilot with a well-marked map that clearly shows each brush area, cutting, or part of a cutting that is to be sprayed. Also, either the COR or one of the observers should make a short reconnaissance flight with the pilot to show him the location of each area to be sprayed and their planned sequence, and to brief him on any special considerations in specific areas.

The COR remains at the heliport and works with the pilot. He makes sure that the herbicides, carriers, and additives are properly mixed, checks calibration of the spray equipment, and makes any necessary viscosity checks before and during spray operations. He is responsible for stopping operations when weather conditions exceed acceptable limits or when equipment must be cleaned or repaired to insure safe application.

The two inspectors follow the operation on the individual spray areas, one inspector to an area. In their separate vehicles, they leapfrog to cover alternating spray areas, provide continual onsite control, and help the pilot to fully utilize all possible spray time. Before the helicopter reaches a new area, they check windspeed, air temperature, and relative humidity, and radio these data to the COR with any other information that may affect spraying. While the area is being sprayed, they make periodic checks on wind, temperature, and humidity, and look for any sign of wind gusts or air movement that might cause spray drift into nontarget areas. They also watch for plugged or leaking nozzles or other defective equipment. They keep the COR and pilot advised of these and any other conditions that may require special care on the part of the pilot or cessation of operations.

CONCLUSION

In closing, one final point must be stressed. The forest environment must be protected from damage or any unnecessary changes or modification of habitats. Whenever we apply aerial sprays, we must be sure that everyone in the vicinity is aware of the helicopters in the air and the activity on the ground. We can also

be sure that at least some of these people will be concerned about effects on the environment and critical of the spray operation. Each of us must make every effort to use herbicides properly, to spray only areas that need treatment, to use minimum amounts of herbicide, and--above all--to prevent damage to adjacent properties and ecologically sensitive areas.

Intensive forest management will require herbicides and every other effective silvicultural tool if we are to provide the forest products that will be needed by future generations. Careless work and needless damage on any spray project can nullify careful work on all others and possibly result in loss of this valuable silvicultural tool.

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Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

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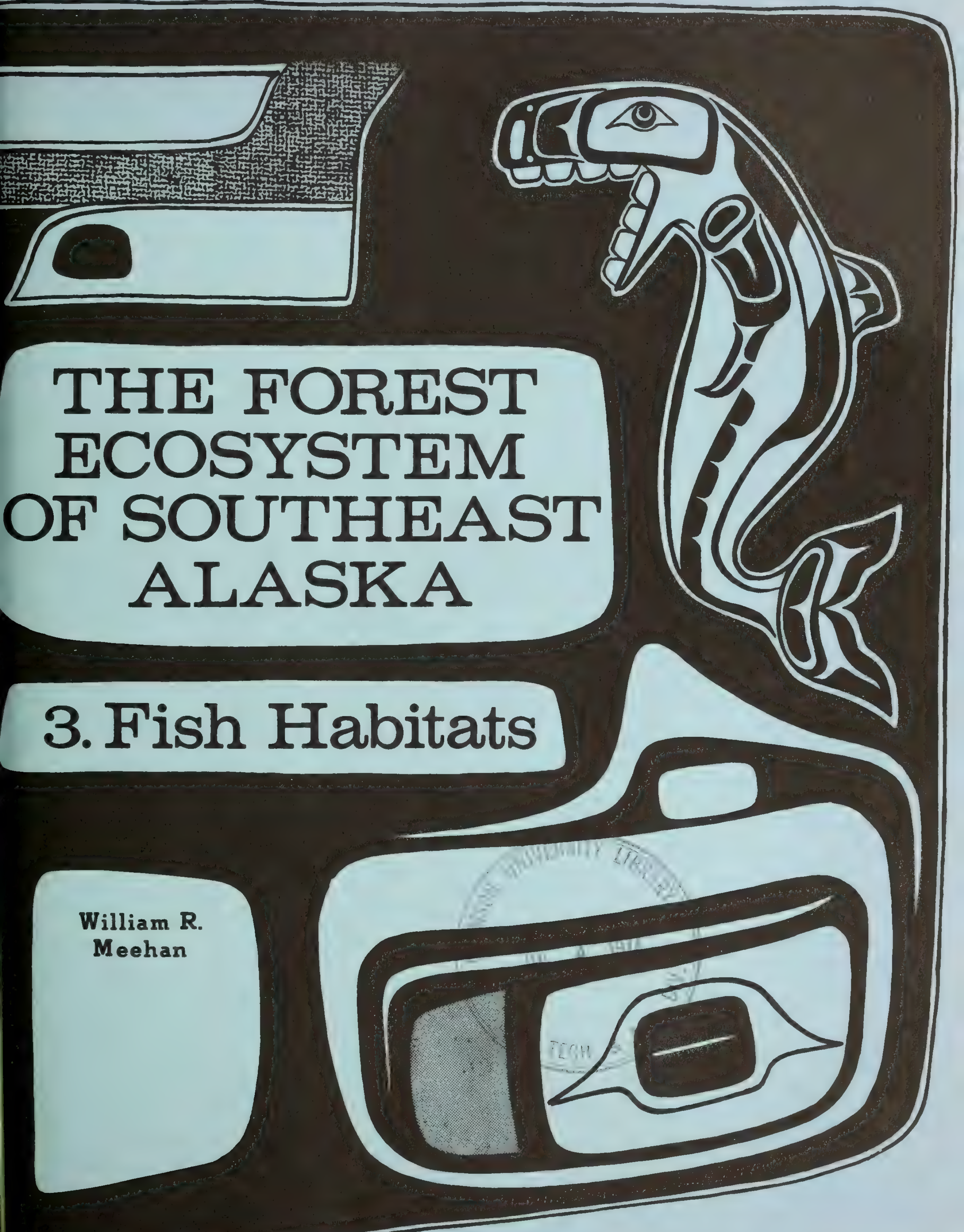

THE FOREST ECOSYSTEM OF SOUTHEAST ALASKA

3. Fish Habitats

William R. Meehan

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U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE

ABSTRACT

The effects of logging and associated activities on fish habitat in southeastern Alaska are discussed, and fish habitat research applicable to southeast Alaska is summarized. Requirements of salmonids for suitable spawning and rearing areas are presented. Factors associated with timber harvest which may influence these habitats are discussed in detail; e.g., sediment, stream temperature, streamflow, logging debris, and chemicals. Recommendations for further research are made.

Keywords: Fish, habitats, research, logging effects.

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PREFACE

This is the third in a series of publications summarizing knowledge about the forest resources of southeast Alaska.

Our intent in presenting the information in these publications is to provide managers and users of southeast Alaska's forest resources with the most complete information available for estimating the consequences of various management alternatives.

In this series of papers, we will summarize published and unpublished reports and data as well as the observations of resource scientists and managers developed over years of experience in southeast Alaska. These compilations will be valuable in planning future research on forest management in southeast Alaska. The extensive lists of references will serve as a bibliography on forest resources and their utilization for this part of the United States.

Previous publications in this series include:

1. The Setting
2. Forest Insects

ROBERT E. BUCKMAN, Director
Pacific Northwest Forest and Range
Experiment Station
Portland, Oregon

CONTENTS

INTRODUCTION

The fisheries resource of southeast Alaska (fig. 1) is dependent largely upon the streams and lakes within the National Forests. These waters are the habitat for several species of salmonid fishes, which contribute materially to the livelihood of everyone engaged in or affected by the commercial fisheries. This is a direct and visible contribution to the economy of the region. These same streams and lakes also are prime habitat for the sport fishes--both anadromous and resident species.[1]

The more important species utilizing the freshwater environment in southeast Alaska are:

Pink (humpback) salmon, *Oncorhynchus gorbuscha* (Walbaum)
Chum (dog) salmon, *O. keta* (Walbaum)
Sockeye (red) salmon, *O. nerka* (Walbaum)
Chinook (king) salmon, *O. tshawytscha* (Walbaum)
Coho (silver) salmon, *O. kisutch* (Walbaum)
Rainbow and steelhead[2] trout, *Salmo gairdneri* Richardson
Cutthroat trout, *S. clarki* Richardson
Dolly Varden, *Salvelinus malma* (Walbaum)

The spawning habitats of the various species of salmon and trout, both anadromous and resident, are basically similar. They must consist of suitable gravel spawning beds and a continuous supply of high quality water, and be protected from physical damage as well as damage to the biological community.

Pink and chum salmon utilize the freshwater habitat only for spawning and subsequent egg incubation. Spawning takes place in late summer and early fall, eggs hatch generally from late November through early January, and the resultant fry emerge from the streambed gravels from late March through early May and most immediately migrate to the sea. Some fry, chums in particular, remain in the stream for a short time. For the most part, however, the feeding and growing portion of their life cycle takes place in the ocean. After 1-1/2 to 3-1/2 years, they return to the streams of their origin to spawn and die.

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[1]An anadromous fish is one which spends part of its life in the ocean and returns to fresh water to spawn. A resident fish is one which remains in fresh water for its entire life. Some species, e.g., rainbow trout, have both anadromous and resident populations.

[2]Anadromous rainbow trout are commonly called steelhead trout when they enter or return from the sea.

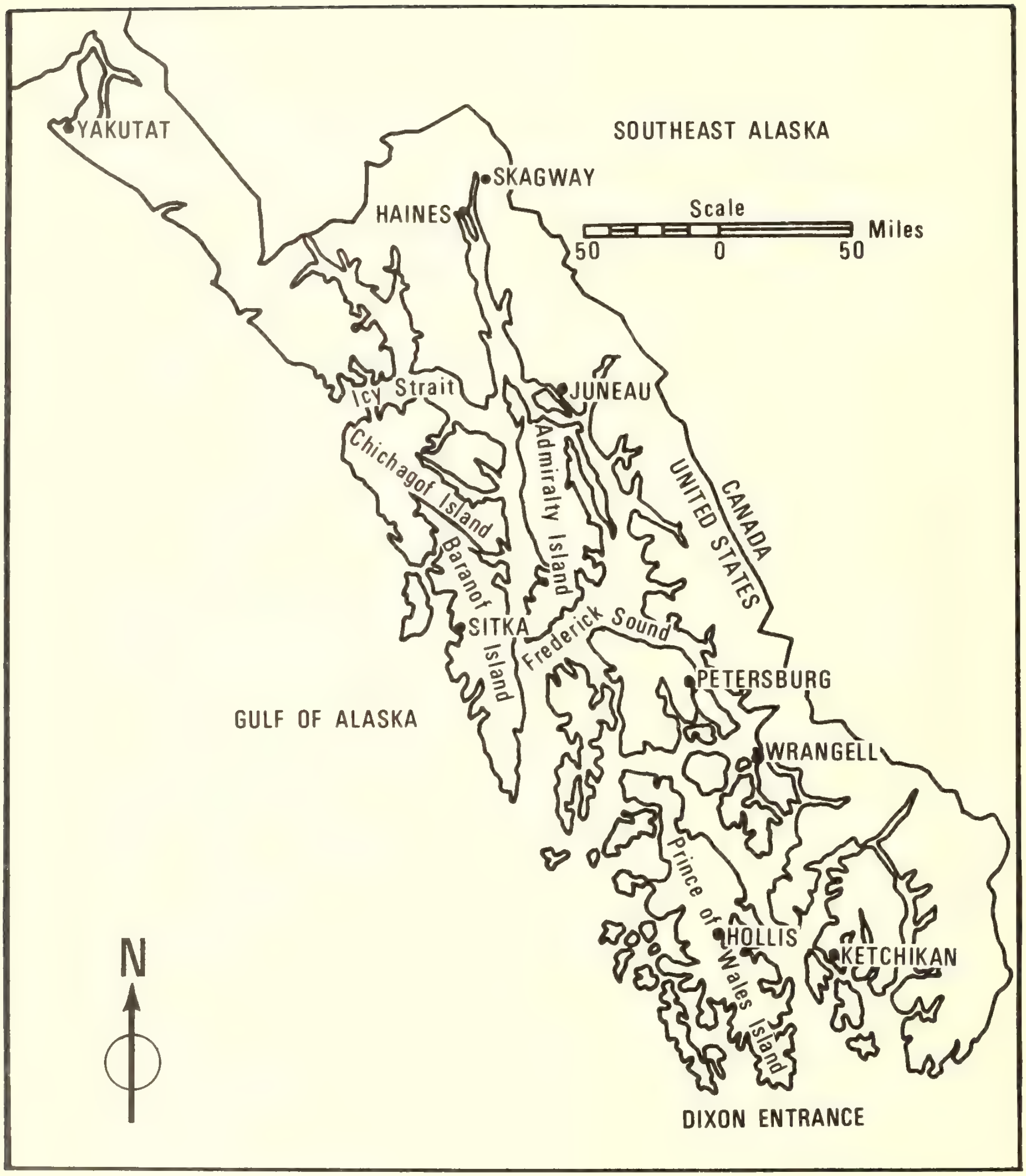

Figure 1.--Map of southeast Alaska east of the 141st meridian.

The sockeye salmon generally requires a lake system for its early rearing. Adults usually spawn in lake inlet streams; the emerging fry drop down to the lake where they spend one or more summers and then migrate seaward in the spring of their second or third year of life. After one or more growing seasons in the ocean (two or three is typical), they return to spawn and die.

Chinook and coho salmon also utilize fresh water as rearing habitat. Chinooks generally favor larger river systems such as the Chilkat, Taku, Stikine, and Unuk Rivers of southeast Alaska. Coho salmon have a much wider range of suitable habitat and will rear in large or small streams, lakes, beaver ponds, sloughs, etc. (fig. 2). Both chinook and coho juveniles spend one or more summers in fresh water before migrating to sea where they remain for 1 or more years before they return to spawn and die.

Figure 2.--Small tributary streams and side channels are important rearing areas for young coho salmon, trout, and Dolly Varden.

Rainbow and cutthroat trout and Dolly Varden char have both anadromous and resident populations. The factor which controls whether a fish will migrate to sea during its life or remain entirely a fresh-water form (assuming both have equal access to the ocean) is apparently genetic.

Rainbow (steelhead) and cutthroat trout spawn in the spring of the year, and the Dolly Varden is a fall spawner. The life cycles of the anadromous forms of these species, although similar to those of the salmon, differ primarily in that trout and char do not die after spawning. In addition, the Dolly Varden has a somewhat more complex life history, e.g., some forms rear in systems other than the one of their origin, some forms are anadromous, and some are entirely fresh-water residents (Armstrong 1965).

Sedimentation and water temperature are the most important habitat factors affecting the freshwater phases of salmon production, although other nondensity-dependent factors such as stability of streambeds and waterflow are also significant. Many of the studies on which this conclusion is based were concerned mainly with pink and chum salmon, species which use fresh water for spawning and incubating eggs but not for rearing young. These have been the main commercial species in southeast Alaska. Other species of salmon and other fishes are increasing in both commercial and recreational importance. The young of these other fishes may live in fresh water for many months, which adds additional factors such as food, cover, and high-quality water the year-around, to the important habitat considerations. Density-dependent factors such as competition for spawning or nursery areas, which place an upper limit on carrying capacity, may be more important than habitat considerations in many cases.

The importance of these factors varies from stream to stream and also according to the environmental requirements of individual fish species. Biologists recognize that evaluation of the importance of these factors may change, and new factors (water chemistry, for example) may prove to be significant as fish environmental requirements are better understood.

SEDIMENT

Sediment in streams is a consequence of natural geologic processes and of certain disturbances due to man's activities. Southeast Alaska is a geologically youthful topography in which mass wasting and valley and stream system development are in particularly active stages. These natural processes create sediment. Steep ground and large amounts of rainfall make the land sensitive to such activities as road construction and log yarding. Ameliorating influences include soils of high permeability and conditions that favor rapid revegetation of disturbed soil.

High mortality of pink salmon has been associated with high stream stages, which cause shifting gravels. Shifting gravels can displace eggs from their protective gravel cover, exposing them to predators, dessication, etc. Shifting gravels can also physically damage eggs and

alevins (preemergent fry) or cause deep burial due to gravel redeposition. High stream stages also move debris, such as logging slash and logs, or stumps and trees excavated from streambanks, which in turn cause gravel excavation and redeposition.

Sampling of streambed gravels shows that gravel composition may include particles from silts and fine sands through large boulders and shapes that range from angular to nearly spherical. These combinations have specific responses, in terms of stability, to stream energy, and should also affect suitability of the habitat for fish.

Under southeast Alaska conditions, the detailed knowledge of quantitative relationships that is needed for accurately evaluating both natural fish habitats and the potentials for habitat improvement and management is generally lacking. However, over the past 50 years, basic concepts concerning mechanics of streamflow and the effects of various stream parameters (depth, gradient, velocity, bedload, channel configuration) on sediment transport and deposition have been developed (Gilbert 1914, Rubey 1938, Kalinske 1947, Brooks 1958, Colby 1961). Recently, attempts have been made to apply these concepts to an analysis of the effects of transported sediments on survival of salmon eggs and alevins (Cooper 1965, Gangmark and Bakkala 1960, [3]). The results of these studies indicate an inverse relationship between stream sedimentation and salmon egg survival.

The principles relating stream parameters to sediment transport and deposition were developed from observations and measurements of streams in watersheds much older geomorphologically than those common to southeast Alaska. The gradients and velocities were much lower, the flows more constant, and the sediment load finer than in Alaskan streams. Consequently, although the basic concepts of stream mechanics and sediment transport remain the same for all streams, quantitative results obtained in these other areas cannot be applied directly to conditions in southeast Alaska.

Sediment, which directly or indirectly affects fish populations, occurs in two forms. The first is "suspended," i.e., as part of the free-flowing, above-streambed water of a stream. In this form it causes the turbid or murky appearance of the water. Suspended sediment has been shown to be harmful to fish if the concentrations of sediment are high and persistent. Cordone and Kelley (1961) have extensively reviewed the literature relating sediment to fish habitat and populations, and most studies have shown similar results. In high concentrations over prolonged periods, silt may accumulate on the gill filaments and actually inhibit the ability of the gills to aerate the

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[3]B. W. Johnson, M. E. Miller, and C. H. Ellis. Egg survival experiments on the north fork of the Stillaguamish River. Unpublished progress report, Washington Department of Fish & Game, 1952.

blood, eventually causing death by anoxemia and carbon dioxide retention. However, sediment concentrations necessary for this direct mortality are generally so high (some studies state lethal concentrations between 20,000 and 100,000 parts per million) that fish populations will be affected in some other way long before these concentrations are reached. Although we can evaluate the lethal concentrations of sediments of different composition, very little is known about the insidious effects on growth and condition of fish.

Another consideration is esthetic and recreational values. Fishermen will not have as high a degree of angling success in turbid waters, since salmon and trout are primarily sight feeders (Phillips 1971). Phillips also suggests that salmon and trout production may be decreased in turbid streams where less desirable species such as squawfish and suckers, which are more tolerant of turbidity, can compete more effectively with the sight-feeding salmonids. Murky water is generally unappealing esthetically, and this factor can impair the recreational value of an otherwise high quality fishing stream.

The second form in which sediment occurs in the stream is "deposited," i.e., as particles which have settled out of suspension and have been deposited on and among the streambed gravels, on aquatic vegetation, etc. Again the effects here take many forms and Cordone and Kelley (1961) have summarized the literature in this area. Some later studies have essentially confirmed their conclusions (e.g., Hall and Lantz 1969, Meehan et al. 1969, McNeil 1966, Cooper 1965, Vaux 1962, 1968, Sheridan 1962, Burns 1972, [4]). The main effect of sedimentation on spawning habitat is the decreased rate of flow of oxygen-bearing waters within the gravels where eggs and alevins are incubating. In addition, sediment may actually act as a physical barrier to the emergence of fry up through the gravel (Hall and Lantz 1969, see footnote 4, [5]). A third effect of deposited or bedload sediment is reduction of habitat used by aquatic insects (Wagner 1959); a reduction of insects in turn may cause a reduction in growth rate and condition of rearing fishes. It is possible that biomass of aquatic insects might not be reduced appreciably, but species composition would be changed. The forms which are intolerant of large amounts of sediments, such as caddis flies (Trichoptera), stoneflies (Plecoptera), and mayflies (Ephemeroptera), would probably be replaced by the forms which live in mud and silt, e.g., midge larvae (Chironomidae). The latter forms, however, would not be as available to fish as the nonburrowing forms (Phillips 1971).

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[4] K Victor Koski. The survival of coho salmon (*Oncorhynchus kisutch*) from egg deposition to emergence in three Oregon coastal streams. M.S. thesis, Oregon State University, Corvallis, 84 p., illus., 1966.

[5] R. W. Phillips, R. L. Lantz, and E. W. Claire. The entrapment effect of 1-3 mm sand on emergent survival of coho salmon and steelhead trout fry. Manuscript being prepared.

Various studies throughout the western United States and Canada have demonstrated how bedload sediment can affect fish production. Cooper (1965) stated that reduction in survival of sockeye salmon eggs and alevins "is in proportion to the reduction of flow of water through the gravel, which in turn varies with the concentration of sediment and the sediment particle sizes." The finer the sediment particles were, for a given sediment concentration, the greater was the reduction in permeability (ability of water to flow through a gravel bed). When permeability is reduced, so is the supply of oxygen to incubating eggs and fry; likewise, waste metabolites (primarily CO_2 and ammonia nitrogen) are not removed at a sufficient rate (Alderdice and Wickett 1958). Alderdice, Wickett, and Brett (1958) stated that chum salmon eggs required from about 1 mg./l. dissolved oxygen during early stages to over 7 mg./l. just prior to hatching; however, their low figure was based on a theoretical extension of a curve on which the lowest observation relating minimum dissolved oxygen to age was about 4 mg./l. In summarizing much of this work, Cordone and Kelley (1961) concluded that sedimentation was one of the most important factors limiting salmonid reproduction in streams.

Limited research in this field in southeast Alaska has essentially confirmed results of studies done elsewhere. In a study of several streams in southeast Alaska, McNeil and Ahnell (1964) showed that streams with more sediment had lower permeability and lower pink salmon escapements. Although clearcutting did result in some increase in suspended sediment concentrations, Meehan et al. (1969) were unable to show a decrease in salmon production in two streams in southeast Alaska. An unfortunate occurrence was that regulations caused the fish traps in Alaska to be removed during the latter part of the study period, at the time when any decrease in salmon populations resulting from logging would have been detectable. Increased escapements due to trap removal would have masked any minor reduction in salmon production as a result of clearcutting. Sheridan and McNeil (1968) likewise observed a temporary increase in fine sediments in spawning gravels immediately following logging in two southeast Alaska watersheds. The amount of fine sediments 5 years after logging began was not significantly greater than prelogging levels. They also noted increases in pink salmon spawners and alevins which were probably due to abolition of fish traps during the study.

Sediment production is a characteristic of the watershed. Sediments can be removed from streambed gravels by redd[6] construction (McNeil and Ahnell 1964), by shifting gravels during high stream stages, and by cleaning devices and other artificial disturbances. The artificial cleaning of streambed sections, however, may also reduce stream-bottom fauna populations which are a major source of food for rearing fishes, at least for a short period of time (Meehan 1971).

[6]Nest dug by spawning fish in which the eggs are deposited.

The discussion of sediment has so far been concerned only with inorganic sediment. Organic sediment is also a possible factor contributing to degradation of fish habitat including water quality. Bark in particular can create a significant oxygen demand as it decomposes, and it also can produce excessive amounts of slime bacteria which then may suffocate incubating eggs and alevins (Hall and Lantz 1969, Burns 1972). Organic debris on the gravel surface can also decrease the exchange of water between the surface and the deeper gravel areas.

In southeast Alaska, most of the limited research on the effects of logging on fish has been done with pink and chum salmon populations, the most valuable commercial species. However, as recreational demands in the region increase, more effort must be devoted to those species which spend all or part of their lives feeding and growing in fresh water (fig. 3). These species include chinook, coho, and sockeye salmon; rainbow (steelhead) and cutthroat trout; and Dolly Varden.

Figure 3.--Cutthroat trout, one of southeast Alaska's important sport fishes.

Most of what we have already discussed regarding the spawning habitat applies to the resident fish populations as well as the strictly anadromous forms. However, we must also be concerned with the rearing habitat of these resident fishes.

The two most important sediment effects on rearing areas are increased oxygen demand by decaying organic sediment and reduction of habitat for preferred aquatic insects. Combinations of factors, such as increased biological oxygen demand and warmer temperatures, are more serious than either of the two conditions separately. Since most organic sediment which finds its way into stream channels can be prevented by careful logging practices (minimizing soil disturbance, falling and yarding away from streams, etc.), there is not much need to expand our discussion at this point.

WATER TEMPERATURE

The principal source of heat which raises water temperatures is direct solar radiation (Brown 1969). When shade-producing streamside vegetation is removed, water temperatures may be increased several degrees. It is often possible to predict the magnitude of this response. The amount of temperature increase depends on such conditions as volume of streamflow, ground water influences, length of stream exposed to solar radiation, and general climatic conditions. Confounding conditions are entry of surface and ground waters. The most drastic changes occur in small streams; many of these small streams contribute significantly to the production of salmon and trout (Lantz 1971b, Brown and Krygier 1967).

Several recent studies have demonstrated how streamside vegetation directly controls water temperature. Brown and Krygier (1970) could not detect any increases in stream temperature as a result of patchcutting a watershed in the Alsea River basin in Oregon, where buffer strips remained to provide shade for the stream. In an adjacent watershed which was clearcut and later burned, mean monthly maximum temperatures were increased by 8° C. (14° F.), and the annual maximum was increased by 16° C. (29° F.) during the first year after treatment. Both annual maximum temperatures and mean monthly maximum temperatures decreased as shade-producing riparian vegetation returned.

Levno and Rothacher (1967) reported that mean monthly maximum temperature increased as much as 7° C. (12° F.) during midsummer in an Oregon stream which was exposed to direct sunlight as it flowed through a small clearcut. In a second stream in which logging debris created some shade, an increase in mean monthly maximum temperature of only 2° C. (4° F.) occurred during the same period.

Burns (1972) reported that protection of riparian vegetation along one California stream prevented temperatures from increasing after logging. In a second stream, maximum temperature increased 11.1° C. (20° F.) during road construction which removed the streamside canopy.

From the summer temperature standpoint, the type of vegetation which creates the shade is probably not important. Brown and Brazier (1972) felt that shrubs were more effective than conifers in providing summer shade. In the winter, deciduous plants will lose their effectiveness after the leaves drop.

In southeast Alaska, effects of shade removal on stream temperatures are consistent with these studies. Meehan et al. (1969) observed a maximum increase in stream temperature of 5° C. (9° F.) in midsummer after clearcutting, although mean monthly maxima increased only 2° C. (4° F.). Meehan (1970) demonstrated how temperatures increase as streams flow through unshaded reaches; shading from streamside vegetation reduces heating of the water and helps to maintain

cool stream temperatures. An ameliorating influence in southeast Alaska is the abundance of cloudy weather which reduces the amount of solar energy reaching the streams.

Winter temperature changes resulting from removal of insulating riparian vegetation is another area in which we lack definitive information. Sheridan (1961) discussed how ice and snow cover has an insulating effect during "closed" winters. However, during "open" winters with little snow cover but with cold temperatures, lack of insulation by vegetation might be important. In southeast Alaska, where sustained periods of well-below-freezing temperatures are common, a slight lowering of water temperature in winter due to back radiation might be more critical than summer increases.

As with sediment and most other factors influencing fish habitat, water temperature must be considered with respect to both spawning and rearing habitat. In some instances a given reach of stream may serve in both capacities, but often emerging fry will seek areas for rearing which are different from the spawning beds. Coho salmon and Dolly Varden, for example, often utilize slow-moving or even still waters (fig. 4). These may be in the form of small tributaries, sloughs,

Figure 4.--Traps are used to evaluate production of juvenile salmonids in small tributary streams.

beaver ponds, or just side meanders of the main stream. The effects of water temperature may be quite different in these different types of habitat. For example, pink and chum salmon utilize fresh water only for spawning and subsequent incubation of eggs and alevins. Although some minor feeding may occur immediately following emergence, feeding and growth are generally considered to take place in the marine environment. In this situation, water temperature plays its main role in regulating the duration and timing of incubation, hatching, and emigration from the freshwater system. A given total number of temperature units[7] is required (from the time of egg deposition and fertilization) for the eggs to hatch. If this development is accelerated by even a very minor temperature increase (2° or 3° F.) due to removal of streamside vegetation, fry may emerge considerably earlier than they normally would in that stream. Downstream migration to the sea might be impeded at that time or conditions for growth and survival in the ocean might be unfavorable at that time of year (Martin 1958). These are considerations that have largely been overlooked until now.

In some situations where water temperatures were warm to begin with, an increase in temperature could contribute to decreased dissolved oxygen supplies and might promote the growth of slime bacteria or fungi which could cause excessive mortality to incubating eggs.

In rearing areas, water temperature changes may affect habitat in different ways. Food organisms such as aquatic insects and other invertebrates may respond to temperature changes in terms of species composition as well as biomass. In some cases this might be favorable. Cold streams, shaded by dense forest canopies, may not be optimum trout habitat (White and Brynildson 1967). Thinning the riparian canopy would allow more solar energy to reach the stream, raising water temperature a few degrees and possibly increasing production of algae and aquatic insects. Burns (1972) reported that in two California streams salmonid biomass increased after areas were carefully logged. This type of treatment must be done cautiously, particularly in streams which are fairly warm to begin with,to avoid increase of nutrients to the point that oxygen deficiencies and generally stagnant conditions are created (i.e., eutrophication). In most cases, a maximum temperature of about 15.6° C. (60° F.) should not be exceeded. Another factor that should be considered in this type of manipulation is that a cold stream may have its greatest value in controlling higher water temperatures in downstream areas.

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[7]A temperature unit (TU) is defined as 1 degree of temperature (Fahrenheit) above freezing for 24 hours; e.g., at 34° F. constant temperature, eggs accumulate 2 TU's per day.

For the most part, this discussion about stream temperature has been concerned with direct effects on mortality or survival of fishes. A less dramatic, but nonetheless important, consideration is the effect of temperature on such factors as growth, condition, and behavior of fish. Fish utilize food best at lower water temperatures (Averett 1969, Lantz 1971a). The reason for this is that food energy is available for growth only after other functions have been satisfied. At warmer temperatures, metabolic rates increase, which uses more energy. Hence, given an equal amount of food, more energy will be available for growth at lower water temperatures. At the same time, however, maximum growth rate occurs at higher temperatures (assuming lack of food is not a limiting factor), even though food conversion is less efficient. Other factors enter into this energy utilization structure, but this one example will serve to show the complex of stream temperature factors. Another consideration is that at lower temperatures fish are more active and, from a recreational standpoint, might be more desirable than if they were taken from warmer waters in which they might be more sluggish and poorer fighters.

In summary of stream temperatures, with our present knowledge we should attempt to maintain shade cover on most streams. The smaller the stream, the more critical is this shade since the influence of solar energy will be more pronounced.

STREAMFLOW

Streamflow is regulated primarily by seasonal precipitation patterns and influenced greatly by evapotranspiration, normal streamflow regime of a given watershed, condition of the soil, and saturation level of groundwater aquifers.

In general, research has shown that after clearcut logging (1) streamflow increases (especially when burning follows removal of logs), (2) minimum streamflow during dry summers is significantly increased, and (3) assuming that soil compaction to the point that soil infiltration capabilities are decreased has not occurred, major peak (flood) flows are apparently not greatly increased (Rothacher 1971). Normal variations in streamflow due to climatic conditions are in most cases greater than variations produced by vegetation removal. In areas where precipitation patterns vary greatly, the effects of evapotranspiration may be difficult to detect (Rothacher 1971).

In southeast Alaska the generally very wet climate may cause streamflow increases after clearcutting to be very difficult to observe. Meehan et al. (1969) were unable to detect differences on two watersheds of Prince of Wales Island.

The effects of increased streamflows on fish populations could be harmful or beneficial, depending on their time of occurrence. Increased flow during periods of naturally high water might cause mortality of eggs and alevins from gravel bed movement and might also flush aquatic insect populations. On the beneficial side, increased flow during normally low flow periods could enlarge the available living space and increase the carrying capacity of the stream for rearing fish. The increased flow at this time of year would also tend to lessen water temperature increases resulting from removal of streamside vegetation. Increased streamflow might also minimize oxygen privation and freezing in spawning beds.

In southeast Alaska, change in streamflow resulting from timber harvest is probably not as significant a problem as it is in other areas.

DISSOLVED OXYGEN AND OTHER WATER CHEMISTRY FACTORS

In any consideration of water chemistry in relation to fish habitat and fish populations, D.O. (dissolved oxygen) surfaces as the most important constituent. We have already discussed some of the effects of dissolved oxygen on fish; however, this factor is sufficiently important to warrant further consideration.

Dissolved oxygen is important in surface waters and in intragravel waters. Oxygen is utilized by the developing eggs in relation to size and stage of development. More oxygen is required as the egg develops, with the maximum requirement just before hatching (Alderdice et al. 1958, Phillips 1971). In general, the greater the concentration of oxygen, the better the growth and survival of eggs and alevins, with highest survival at the saturation level of about 11 mg./l. (Shumway et al. 1964, Silver et al. 1963, Phillips and Campbell 1962).

After hatching of the fry and emergence from the gravel, dissolved oxygen is important in maintaining the "fitness" of young salmonids living in the stream. Feeding activity and growth (and consequently survival) are generally better in waters with higher dissolved oxygen concentrations (Narver 1971).

After felling of streamside timber along Needle Branch (a tributary of Drift Creek in Oregon's Alsea River watershed), reduction in D.O. was first noted in the intragravel water (Hall and Lantz 1969). A layer of debris on the gravel surface, combined with ponding of surface water, caused a reduction in the rate of interchange between surface and intragravel waters. This reduction, plus the oxygen demand from decomposition of logging debris, caused a rapid decline of oxygen in the intragravel water. An oxygen deficiency was noted in surface waters soon afterward.

Other chemical considerations are often directly associated with D.O. Increase in carbon dioxide, ammonia, and other metabolic waste products of developing eggs and alevins are often found along with low D.O. levels. This is usually the result of reduced flow of water within the gravel beds, because oxygen is not adequately replenished and metabolites are not satisfactorily removed. In most cases when D.O. is adequate, these other factors are not cause for concern. In extreme cases, such as a small, slow-moving stream choked with great quantities of fine logging debris, anaerobic bacteria could possibly cause the production and release of hydrogen sulfide gas which could be a serious cause of mortality to young salmonids (Narver 1971). However, other problems (e.g., dissolved oxygen reduction) would probably be evident before this kind of situation would arise, and would be of overriding importance relative to the survival of salmonids.

LOGGING DEBRIS AND LOG JAMS

Logging debris is considered here as the leaves, branches, bark, tops, and other nonmerchantable material resulting from logging operations which finds its way into the stream channel. It may cause oxygen deficiencies in several ways, such as (1) creating an oxygen demand as it decomposes, (2) forming a barrier on the gravel surface which reduces the interchange of surface and intragravel waters, (3) impounding waters which normally would flow over riffles and be oxygenated, (4) producing slime bacteria which smother developing eggs, and (5) contributing to temperature increases as a result of reduced water velocity through unshaded reaches of stream. Narver (1971) has summarized the literature in this area, and most studies have confirmed the foregoing points.

Aside from creating oxygen deficiencies, fine logging debris can cause changes in the habitat of aquatic insects and hence affect fish populations. Accumulated debris can likewise fill in the interstices of gravel and rock areas, effectively reducing the living space of some insects and an important type of cover for small juvenile fishes, and decreasing the survival-to-emergence of alevins if the accumulation takes place during egg incubation.

The most obvious effect of log jams is to block fish passage to upstream spawning and rearing areas. Large jams also have a significant bearing on streambed topography, gravel stability, sediment deposits, and streamflow (Helmers 1966).

Thus far we have considered factors which are primarily harmful to fish populations. In some ways logging debris and jams may serve beneficial roles. Streambed movement associated with log jams may serve a useful purpose by accelerating the flushing of fine sediments from the gravel (Meehan et al. 1969, Helmers 1966); however, the effects of sediment flushing on downstream areas, including the estuaries, must not

be overlooked. Dense accumulations of large debris across the stream channel can provide shade to lessen the impact of solar energy on water temperature. In otherwise fast-flowing streams, some impounding could provide rearing areas for trout and coho salmon. Feeding and escape cover might also be a function of relatively stable debris jams.

Uphill felling of timber has been suggested as a means of keeping logs and debris out of streams (Burwell 1971). This method was considered for old-growth timber in steep V-notch drainages in the Pacific Northwest, where reduced breakage made it economically advantageous. In southeast Alaska, most of the larger timbered drainages have glacier-formed, U-shaped valleys. In the latter situation, it should be easier to keep logging debris out of the stream channel in the first place.

Each accumulation of debris in a stream (whether natural or man-caused) should be treated as an individual case, based upon the various potential effects of removing it or leaving it in place. With our present knowledge of the effects of debris accumulations, we can say that our first concern is to keep logging debris out of the stream channel. Next, debris should be removed with the least possible disturbance to the streambed and the banks. This precludes the use of heavy machinery in the stream and probably means removal by hand. Fine debris can be considered harmful to the aquatic ecosystem in all cases. Logs, either in jams or individually, should be considered from several aspects before they are removed. If spawning area is the factor limiting fish production in a given stream, the material should probably be removed; if nursery or rearing habitat is the limiting factor, some impoundment by log jams which do not restrict passage of fish may be desirable. The various effects of debris on streamflow, dissolved oxygen, water temperature, sediment, fish food supplies, quantity and quality of spawning and rearing areas, and perhaps even recreational and esthetic values must all be heeded before a decision is made to remove or to leave debris.

FOREST CHEMICALS

Modern land use treatment practices utilize a large number of chemicals including herbicides, insecticides, and fertilizers. Norris and Moore (1971) and Thut and Haydu (1971) have summarized the literature concerned with the entry and fate of forest chemicals in streams and their effect on aquatic life. Their conclusions are that most forest chemicals have minimum pollution potential. It should be stressed that the behavior of each chemical and formulation and the effects on aquatic life must be known before widespread application.

In southeast Alaska, widespread use of forest chemicals has not occurred, although a few relatively minor treatments take place each year. Most of these are local applications of insecticides in the

vicinity of campgrounds or of herbicides along roads and airfields to control brush. Applied by hand, they are no problem to aquatic habitat since the chemicals can be applied directly to target organisms and kept away from water surfaces. Care must be taken after spraying not to clean equipment in and flush excess chemicals into the streams and standing waters.

In the last few years there have been a small number of larger operations in which chemicals were applied aerially. The two commonly used chemicals in southeast Alaska have been the herbicide 2,4-D and urea fertilizer. In the aerial application of these chemicals, areas of several hundred acres have usually been treated.

Large-scale application of insecticides for control of forest insects is not now practiced in southeast Alaska. However, between 1961 and 1964, the effects on fish and aquatic insects of an aerial application of DDT (0.28 kg./ha. or 1/4-lb./acre) to control black-headed budworm were studied in four streams on Prince of Wales Island (Reed 1966). Although fish mortality was not demonstrated, this study did show a drastic reduction in populations of aquatic insects for a year after treatment and a resultant decrease in growth and condition of trout for 2 years after treatment. Although this type of treatment might not have significant influences on pink and chum salmon, the rearing species (coho, chinook, and sockeye salmon, cutthroat and rainbow trout, and Dolly Varden) could be seriously affected by reduced food (fig. 5).

Figure 5.--Quantity and species composition of streambed fauna being sampled here provide a means of evaluating stream productivity.

At the present time, 2,4-D is the only herbicide used extensively in southeast Alaska for the control of undesirable plants. In 1968, the U.S. Forest Service treated with 2,4-D approximately 400 acres of cutover land on the Nakwasina River watershed on Baranof Island to inhibit the growth of broad-leaved plants. The effects of this treatment on water quality and aquatic life were reported by Sears and Meehan (1971). No immediate mortality to salmonid fishes or aquatic insects was attributable to the spray, and samples of water and fish had concentrations of 2,4-D well below the level generally considered lethal to aquatic organisms. This study dramatically pointed out the lack of knowledge of the properties and effects of 2,4-D and resulted in a rigorous testing of the acute toxicity to salmonid fishes of several formulations of the chemical.[8] Of the esters tested, the butyl ester and the propylene glycol butyl ether ester were much more toxic to salmonids than the isooctyl ester. Since the esters are all equally effective in controlling the undesirable plants, the isooctyl ester should be used for aerial applications where there is any possibility of the chemical falling directly on surface waters.

The small amount of forest fertilization in southeast Alaska has been with urea fertilizer. This fertilizer generally contains 46 to 47 percent nitrogen and is applied at the rate of 400 pounds (200 pounds of nitrogen) per acre. Studies done elsewhere (summarized by Norris and Moore 1971) have shown that ammonia nitrogen is the most toxic product of urea fertilizer to aquatic organisms, but that lethal concentrations have never been approached in the field. A recent study in Alaska[9] showed similar results, with an initial increase in ammonia which lasted for only a short time. Nitrate concentration in water samples showed a slight increase after fertilization but was probably not enough to stimulate a significant increase in stream productivity.

ESTUARINE HABITAT

The absence of roads and the distances between sale areas and processing mills in southeast Alaska have resulted in the extensive use of salt water for storage and transportation of logs. Wood-boring organisms, such as teredos, are inhabitants of these marine waters, so logs are generally stored in shallow bays which drain dry at low tide. Protection from strong winds is another factor in storing logs in estuarine coves.

During the log dumping and rafting processes, bark is knocked off the logs and sinks to the bottom, often in large quantities. This

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[8] W. R. Meehan, L. A. Norris, and H. S. Sears. Toxicity of various formulations of 2,4-D to salmonid fishes in southeast Alaska. Journal of the Fisheries Research Board of Canada, in press.

[9] William R. Meehan, Frederick B. Lotspeich, and Ernst W. Mueller. Effects of forest fertilization on two southeast Alaska streams. Manuscript being prepared.

accumulation can greatly increase oxygen demand, resulting in reduced populations of marine benthic organisms, and also smother the bottom so thoroughly that repopulation by benthic forms is prevented (Pacific Northwest Pollution Control Council 1971).

Observations at several dump sites in southeast Alaska showed that significant accumulations of organic debris may persist for long periods of time (Ellis 1970). Marine animals, including crabs and clams, were very scarce in some areas. In general, the impact of these log facilities depends on several conditions including the type and age of the facility and the characteristics of the water (depth, influence of tidal currents, etc.).

Water storage of logs also results in a release of soluble organic compounds (leachates) which further increases the oxygen demand in the storage area. Length of storage, species of logs stored, and various estuarine conditions all influence the effects on marine communities (Schaumburg 1970).

Much remains to be learned about the effects of water-based log handling in southeast Alaska. The economic as well as biological considerations involved in rafting and towing versus barging, for example, need to be determined. In general, any method which reduces the amount of bark and other log debris which accumulates on the bottom should be considered.

HABITAT IMPROVEMENT, EFFECTIVENESS/COST[10]

Streams and lakes in Alaska provide excellent opportunities to enhance habitat, to increase production of salmon, and to attach a dollar value to the improvement. Although the salmon resource may be recovering very slowly from low levels, increased production would help both the fisherman and the industry.

At the present time both the Alaska Department of Fish and Game and the U.S. Forest Service are engaged in stream improvement programs. These include such activities as: (1) debris and log jam removal, (2) construction of fish ladders or steeppasses over barrier falls, (3) construction of spawning channels, (4) removal of beaver dams, (5) removal of blowdown, and (6) gravel cleaning. The Forest Service has been instrumental in development of a machine for removing sediment from streambed gravels. The "riffle sifter" is a self-powered amphibious vehicle which stirs up the gravel, sucks out the fine sediments and sprays them onto the streambanks. Although this machine shows promise,

[10]Much of this section is excerpted from "Benefit/Cost Aspects of Salmon Habitat Improvement in the Alaska Region," by W. L. Sheridan, USDA Forest Service, Region 10, February 1969, 47 p.

basic mechanical problems require redesign. In conjunction with the gravel cleaning operation, a study in southeast Alaska showed that aquatic insect populations were reduced as a result of treatment, but that biomass returned to precleaning levels within a year (Meehan 1971).

During project inventory and planning by the Forest Service, it became apparent that a method was needed whereby the dollar value of a potential improvement could be established. This would permit establishment of priorities and a basis for requesting funds to accomplish a realistic, planned, habitat-improvement program over a period of time. Such a method was developed, using the effectiveness/cost analysis approach. The effectiveness/cost analyses are equally applicable to both commercial and sport fisheries.

Developing such a method was not easy for two reasons. First, there is apparently some confusion among economists regarding the economics of sport and commercial fisheries. Second, and this factor exerts an even more profound influence on results, is the difference in the *quality* of spawning and rearing areas in different lake and stream systems. Since much is unknown of the influence of this quality, and only crude methods have been developed by which to measure it, potential benefits must at present be calculated on the basis of *quantity* of spawning and rearing areas and *average* survival rates presented in results of research carried on in the past 20 plus years.

This effectiveness/cost analysis has distinct advantages in that it enables priorities to be set so that alternatives can be chosen. There are limitations, however, some of which are as follows:

1. Costs are estimated as closely as possible. If actual costs exceed estimated costs, the actual effectiveness/cost ratio is decreased; if actual costs are less than estimated costs, the actual effectiveness/cost ratio will be increased.

2. Yields are calculated on the basis of average survival rates and normal production from an "average" environment. Until practical methods are developed to evaluate the quality of spawning and rearing areas, production must be based on quantity. Obviously the quality of different spawning and rearing areas can vary considerably. In some instances, this means that by using average production figures, actual production will exceed the estimated production, and in other cases actual production may fall well below the estimated figure. Production of salmon also depends to a large extent upon climatic factors--rainfall, temperature, and others.

3. Dollar values are used in the effectiveness/cost analysis. Changes in costs of construction and in the price of fish will affect the effectiveness/cost ratios.

We will gain a better understanding of these limitations as more

projects are completed and evaluated. It may be necessary to change some of the constants used in calculating yield as more information is obtained.

The economic desirability of a fish habitat improvement project can be measured by the amount of yield the project will give beyond that already established for the environment as it existed prior to modification. Needed for different types of improvement are: (1) project cost, (2) maintenance cost, (3) increased yield by year, and (4) an effectiveness/cost ratio adjusted by discounting.

Yield is given in dollar value of the fish at the price-to-fishermen level. By multiplying the value to the fisherman by 2.5, a rough wholesale (case-pack) value can be obtained. The further values are carried, however, the more complex they become. For example, wholesale and retail values should include all the costs incurred in catching, processing, and marketing, and these costs are difficult to come by.

Estimating effectiveness/cost ratios has been programed by the Fisheries Research Institute, University of Washington, Seattle, Wash. 98105.

DISCUSSION AND SUMMARY

Fish and timber are the two most important natural resources in southeast Alaska at the present time (fig. 6). Salmonids (Pacific salmon, trout, and char) often spend most of their freshwater life in

Figure 6.--Important fish and timber resources frequently share the same valley, as here on Prince of Wales Island.

streams that flow through forested watersheds. In the glacier-formed, U-shaped valleys common in southeast Alaska, much of the best timber is found in the valley bottoms in close association with salmon and trout streams. This makes timber harvesting a more difficult problem, because timber harvesting can affect streams.

Two major freshwater habitat types are important to salmonids, i.e., spawning areas and nursery or rearing areas. In some cases a reach of stream may serve as both spawning and rearing habitat, but more often rearing areas are located some distance away from the major spawning riffles. Pink and chum salmon utilize spawning habitat; but after fry emerge from the gravel beds, they migrate to sea almost immediately, so that freshwater rearing areas are not significant factors in their life cycle. On the other hand, the remaining salmon species (coho, chinook, and sockeye), the trouts (rainbow and cutthroat), and the char (Dolly Varden) spend from a few months to 3 or 4 years in fresh water before migrating to sea; in some cases they spend their entire life in fresh water. To these species the rearing areas are often more important than spawning habitat (although both can be critical), since the amount and quality of "living room" is generally the factor which limits their production.

The primary function of spawning gravels is to provide an environment suitable for the development of the eggs and alevins up to the time of hatching and emergence. The rearing areas must provide conditions suitable for the growth and survival of the young fish. Because of these different requirements, the two habitat types may be quite dissimilar. The spawning environment must (1) contain sufficient quantities of suitable gravel, (2) provide sufficient surface and intragravel water flow to assure adequate flow of oxygen to and removal of metabolic wastes from the developing embryos, (3) maintain temperatures which assure proper rate of development and time of emergence of the eggs and fry, and (4) be free of sediment in quantities which would inhibit development of embryos and emergence of fry. The rearing environment must provide the food, living space, cover, and water quality necessary for good growth and survival of fish populations. The spawning reaches are generally characterized by series of riffles and pools, where the flowing surface water can be oxygenated, and where bottom contours favor the interchange of surface and intragravel waters. The rearing habitat is often slow-moving water, rich in plant and invertebrate animal life, and ranges from small streams and tributaries through sloughs and side channels of major streams and rivers to ponds and lakes of varying size.

Consideration for fish habitat in southeast Alaska during timber harvesting was in the past often directed only toward the larger spawning streams. Today, the great importance of the smaller rearing areas is being more fully recognized, and these areas are now beginning to receive the attention which they warrant. Small streams are generally more dramatically affected by changes than are larger streams and rivers.

Sediment (both suspended and deposited), water temperature, dissolved oxygen, streamflow, and debris are the factors associated with logging practices which can affect the habitat of anadromous and resident fish populations. These factors often are interrelated, and the total cumulative effects may be greater than the sum of their individual effects. For example, if streamside shade is removed from a reach of stream, water temperature will be increased. If logging debris accumulates in this reach, dissolved oxygen levels may be reduced. If sediment is introduced, intragravel water flow and the interchange between surface and subsurface waters may be inhibited. Each of these factors might cause a reduction in salmon egg survival if it was the only factor involved. However, if all three conditions were to occur simultaneously, still greater effects could be produced. Increased water temperature would increase the oxygen demand produced by the decomposing debris, thereby further decreasing the dissolved oxygen content of the water. The sediment would decrease the interchange and flow of water through the gravel, further limiting the amount of oxygen reaching the embryos and also inhibiting removal of waste products produced by the embryos and the decomposing debris. The total effect on the developing eggs of this combination of conditions could be much more disastrous than the sum of their individual influences.

Sediment and fine logging debris (bark, leaves, twigs) are not compatible with high quality fish habitat. There is an inverse relationship between the accumulation of these materials and salmonid production. This consequence must be considered when timber sales are laid out and during logging (e.g., road location, falling, and yarding away from streams).

Water temperature is controlled by the amount of solar energy reaching the stream. Such factors as surface area of stream, amount of streamflow, groundwater, and tributary influences may ameliorate the effects, but shade is of greatest importance. As shade cover is removed, summer water temperatures will rise. Within limits, temperature increases in small streams as a result of removing streamside vegetation can be predicted. In some situations a slight warming of stream water might enhance fish production, but the cumulative downstream effects of temperature increases in upstream tributaries must be considered.

Log jams and large debris may limit fish production in one stream; in another stream this material could be beneficial.

Streamflow should increase as a result of clearcutting. In southeast Alaska there is no evidence that this is a major factor in causing increased storm flows. The climate and high infiltration rates of the soil probably account for the inability to observe streamflow increases.

Many of the factors which have been discussed in this report are

difficult to measure because often natural variation can be greater than the variation caused by man. For example, if severe storms occur during the measurement period, small changes in suspended sediment concentration or streamflow as a result of roadbuilding or logging might go undetected. Natural variations in stream temperature are also a potential problem in identifying temperature changes resulting from man's activities.

In summary, man's activities in a watershed can affect fish habitat. These activities (logging, road construction, etc.) can be compatible with the production of salmonid fishes if adequate consideration is given to the aquatic environment during both planning and operational stages. Protection of our fish-producing waters in conjunction with land use treatments is a responsibility which our land managers must never overlook. Fishery biologists must help determine the type of protection necessary for each stream system, and foresters must plan timber harvest in that system to assure that the necessary protection is afforded.

RESEARCH NEEDS

Much is known about the effects of man's activities on fish habitat. Using our present knowledge, we can fairly well predict how various treatments of a watershed will affect the streams within that watershed. We know, for example, that poor road layout and construction methods and improper log yarding can cause sediment in streams. We know that removal of shade-producing vegetation from the streambanks will raise the water temperatures during the summer months. We can assume that clearcutting in a watershed will result in increased streamflow. We know that accumulations of fine logging debris in a stream can cause reduced levels of dissolved oxygen.

However, we need to know more than just the ways in which these changes to the stream may be brought about. We must be better able to define the changes to the aquatic habitat which result from man's activities. We also need to know just what effects these changes will have on fish populations. For example, it is not enough to know that stream temperature will be increased when streamside vegetation is removed. We must be able to determine precisely what these changes will be under different conditions, such as amount and kind of shade cover which will remain along the stream. And we must know how these various changes will affect the fish and their food supplies. One of our biggest needs for future research is to define the response of the aquatic ecosystem to stream changes resulting from land treatment practices.

In the area of sedimentation, one of the most important questions to be answered is, *How much sediment can salmonid populations tolerate?*

This type of information is necessary before alternatives can be selected and a decision made regarding treatment within a watershed.

The same question needs answering with regard to water temperature. *How much temperature change can salmonid fishes tolerate without a loss in production?* Leave, or buffer, strips along streams need much more study before the ramifications of their presence or removal can be clearly understood. The type of riparian vegetation which can produce the shade necessary for maintaining suitable water temperatures should be determined, as well as the rate at which it can be established along a watercourse. The effects on water temperature of various cutting patterns should be determined.

The merits of removing or maintaining debris jams in various situations need to be explored in considerable detail in southeast Alaska. *How do debris accumulations affect spawning areas, and how do they influence fish production in rearing areas? When can strategically placed material improve the habitat for salmonid fishes?*

When forest chemicals are used, we must be certain that we know the immediate effects on the aquatic ecosystem. In many cases this is already known, and in others it can be ascertained easily. However, much more research is necessary before the chronic effects of these chemicals on our aquatic resources will be fully understood. Also, we should know how materials associated with forest chemicals (e.g., carriers and surfactants) react in the aquatic environment. Laboratory bioassay studies are important, but it is also necessary to evaluate these chemicals in the field.

Habitat improvement programs, in both treated and untreated watersheds, are one way in which salmonid production can be maintained or increased. However, some streams may be inherently capable of greater fish production than others. This potential productive capacity is probably controlled by natural factors. A research program to identify the watershed factors which influence fish production is a necessary prerequisite to effective stream improvement operations. It would be wiser to expend money and effort in systems which were capable of substantially greater production than to do so in systems which could never be good producers. This may have the highest priority in southeast Alaska fish habitat research.

All the points discussed here are steps necessary in developing guidelines for the land manager to use in making decisions with regard to watershed use. The ultimate goal of research in this field is to provide the resource manager with a knowledge of the consequences of various land uses with respect to fish habitat and a system for making alternative decisions to obtain the best possible balance of resource values. A modeling and systems analysis approach to achieving this goal should be thoroughly explored.

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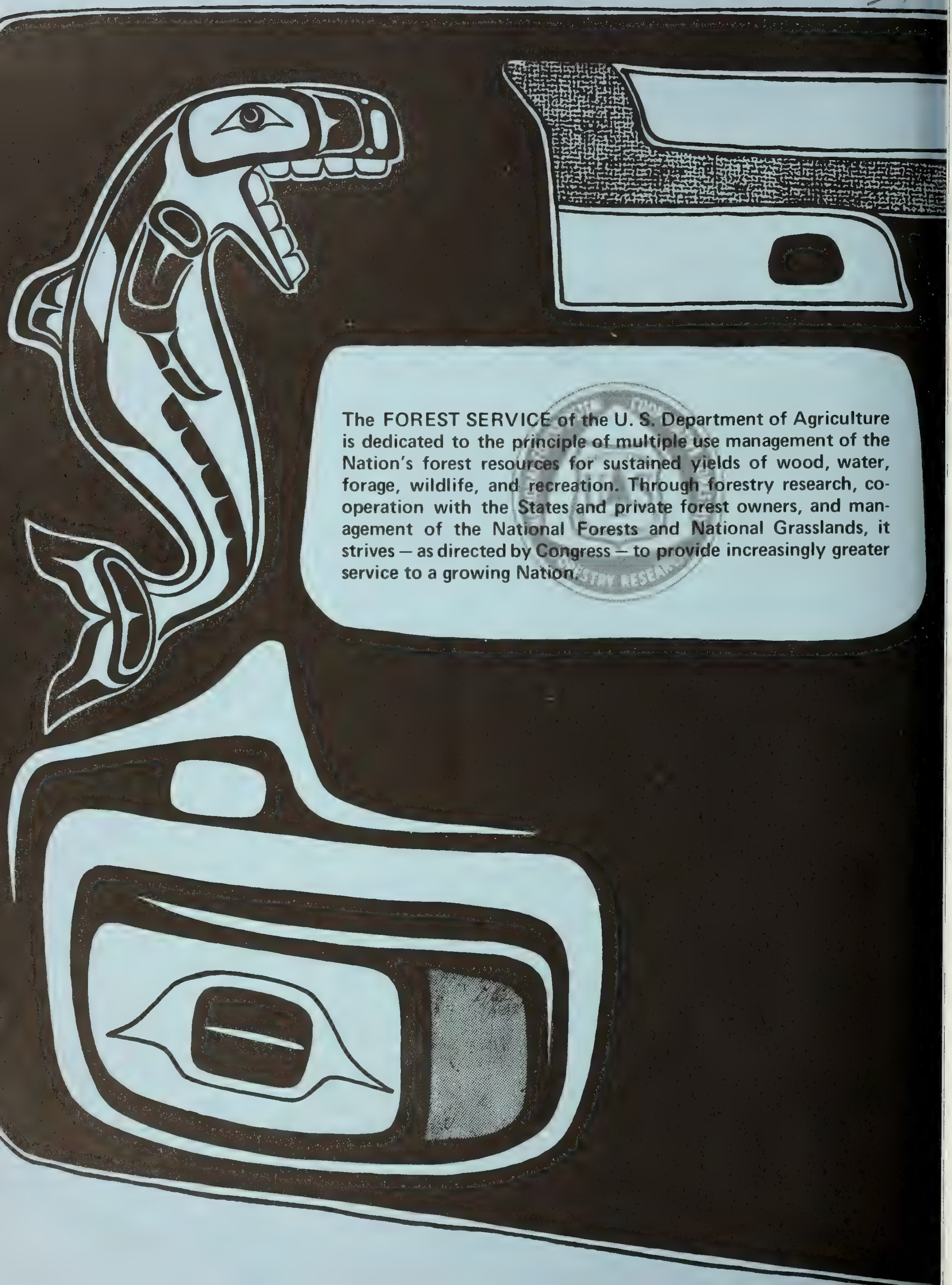

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